TEREX

OPERATOR'S MANUAL

RT700

Revised: February 2006

12261-265

CONSTUCTION AND INDUSTRIAL EQUIPMENT
PRODUCT SAFETY

It is the responsibility of the owner of the construction and industrial equipment products to be knowledgeable about federal, state and local regulations that effect the total usage of his equipment, and responsibility to working personal and the public. Since regulations are subject to change, and also differ from one local to another, this manual makes no attempt to provide such information.

Terex Cranes provides appropriate operation and maintenance manuals for various construction and industrial equipment products that it manufactures and sells. In addition, where applicable, appropriate national consensus standards, industry standards and safety related manuals are included with the Terex manuals in the shipment of each product. It is company policy to provide this information for the owner or user of the equipment. It is expected that the owner or user will utilize these manuals and standards to provide the appropriate information and training to those people who are to operate, maintain and supervise the use of equipment in a proper and safe manner.

Construction and industrial equipment is designed and manufactured to perform heavy-duty work. Under normal usage, the equipment will wear. For this reason it is essential that the owner/user establish and perform a periodic inspection of the equipment. The objective of inspection programs is to prevent accidents, reduce downtime and keep the equipment working efficiently. These inspection programs should be designed to discover worn, cracked, broken or deteriorated parts and loose or missing fasteners before they result in a problem.

Proper training and inspection programs are essential to avoiding injury to persons, damage to property and excessive maintenance costs.

Read and understand the manuals provided with this equipment. Assistance is available from the distributors of your Terex product and from the Terex manufacturing facility.

WARNING

When operating a hydraulic crane, the operator should realize that hydraulic and structural competence, NOT TIPPING LOAD, is often the determinant of lifting capacity.

Therefore, THE OPERATOR MUST BE GUIDED SOLELY BY THE APPROPRIATE MANUFACTURER'S LOAD RATING CHART when considering load weights. The manufacturers rated loads must never be exceeded.

Follow the recommended operating and maintenance procedures and keep your machine operating at MAXIMUM EFFICIENCY. Use the Suggested Crane Periodic Inspection Check List provided. In addition, we STRONGLY URGE that a MAINTENANCE LOG be kept in conjunction with all maintenance performed on the machine.

If you desire any special information regarding the care and operation of the machine, we will gladly furnish it upon request. Because we build various types of equipment, we ask that you include your machine model and serial number in all correspondence so that we can provide the correct information.

The information, specifications, and illustrations in this publication are based on the information in effect at the time of approval for printing. We reserve the right to make changes at any time without obligation.

SUGGESTED ROUGH TERAIN CRANE INSPECTION CHECK LIST

This check list is to be used in addition to the information provided in this manual to properly operate and maintain the machine.

ITEMS TO BE INSPECTED & CHECKED	INSPECTION CODE	SATISFACTORY	ADJUST	REPAIR
VISUAL INSPECTION H (Complete Machine)	D			
OVERALL CLEANLINESS	D			
HYDRAULIC SYSTEM (Leaks or Damage)	D			
AIR SYSTEM (Leaks or Damage)	D			
HYDRAULIC FLUID	D			
AXLE LOCKOUT SYSTEM	D			
TRANSMISSION FLUID LEVEL	D			
ENGINE CRANKCASE FLUID LEVEL	D			
FUEL TANK FLUID LEVEL	D			
RADIATOR FLUID LEVEL	D			
MACHINE LUBRICATION	D			
ATTACHMENT PIN BOLTS	D			
MUFFLER/EXHAUST SYSTEM	D			
ALL CONTROL MECHANISMS	D			
INSTRUMENT GAUGES	D			
CLUTCHES & BRAKES	D			
WIRE ROPE, SHEAVES & GUARDS	D			
TWO BLOCK DAMAGE PREVENTION SYSTEM	D			
LOAD SUPPORTING COMPONENTS CONDITION	D			
FIRE EXTINGUISHER	D			
BACKUP ALARM	D			

ITEMS TO BE INSPECTED & CHECKED	INSPECTION CODE	SATISFACTORY	ADJUST	REPAIR
BOOM ANGLE INDICATOR	D			
HEAD/TAIL/BRAKE LIGHTS & 4 - WAY FLASHERS	D			
HORN	D			
CABLE SPOOLING PROPERLY	D			
WEDGE SOCKETS	D			
AXLE FLUID LEVEL	W			
SWING REDUCER FLUID LEVEL	W			
DRIVE SHAFTS & U JOINTS	W			
TIRE & WHEEL CONDITION & INFLATION PRESSURE	W			
AIR REGULATORS	W			
AIR CLEANER ELEMENT	W			
CLUTCH & BRAKE LINKAGE & PINS	W			
WHEEL LUG NUT TORQUE	W			
FAN BELT TENSION	W			
STRUCTURAL MEMBERS & WELDS	W			
BOOM INSPECTION	W			
BATTERIES & STARTING SYSTEM	M			
ALCOHOL EVAPORATOR	M			
SWING BEARING BOLT TORQUE	P			
MACHINERY GUARDS	P			
LOAD CHART & SAFETY WARNINGS	P			

H Inspect OVERALL machine (including carrier) for cracks, weld separation, leaks, damage, vandalism.

INSPECTION CODE INTERVALS

D - DAILY　　M - MONTHLY

W - WEEKLY　　P - PERIODIC

NOTES:

1. Indicate inspection result by checking in the satisfactory, adjust, or repair boxes provided.
2. When appropriate, enter your diagnosis on back of page for repairs or adjustments made.

REPAIRS - ADJUSTMENTS - REMARKS

ITEM	REQUIREMENT	DATE

NOMENCLATURE

This manual contains instructions and information on the operation, maintenance, lubrication and adjustments of the Rough Terrain Crane. The operator should not attempt to operate the machine before he has gained a thorough understanding of the material presented in the following pages.

To aid in understanding the contents of this manual, the following terms will always have themeanings given whenever they are used.

1. UPPERSTRUCTURE

The upperstructure weldment, swing mechanism, counterweight, cab.

2. BOOM ATTACHMENT

The telescopic crane boom with hydraulic winch, lift cylinder, hook block assembly, jib arrangement.

3. CARRIER

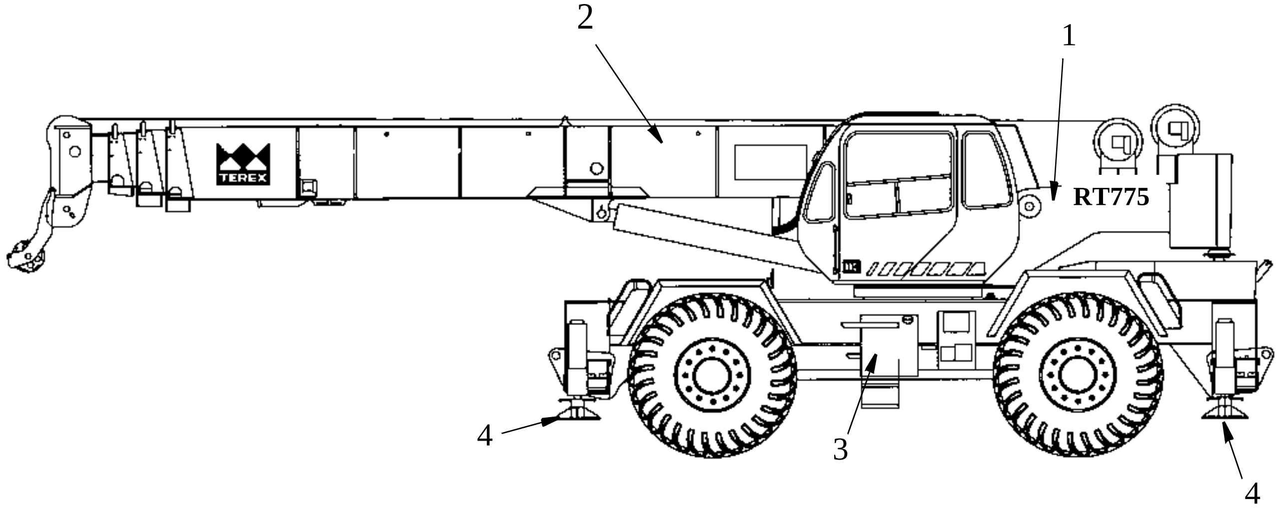
The chassis complete, power unit, swing bearing, transmission, planetary axles, outrigger assemblies.

4. OUTRIGGERS

The beams, cylinders, floats, boxes, hydraulic control system.

RIGHT HAND/LEFT HAND

All references to right or left hand will correspond to the operator's right or left hand when he is facing forward from the operator's seat, with the rear mounted engine to his back.



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SECTION 1

SUBJECT **PAGE**

INTRODUCTION

Owners, Users, and Operators:

Terex Cranes appreciates your choice of our machine for your application. Our number one priority is user safety, which is best achieved by our joint efforts. We feel that you make a major contribution to safety if you as the equipment users and operators:

1. **Comply** with OSHA, Federal, State, and Local Regulations.
2. **Read, Understand, and Follow** the instructions in this and other manuals supplied with this machine.
3. **Use Good, Safe Work Practices** in a common sense way.
4. **Only have trained operators** - directed by informed and knowledgeable supervision - running the machine.

NOTE: OSHA prohibits the alteration or modification of this crane without written manufacturers approval. Use only factory approved parts to service or repair this unit.

If there is anything in this manual that is not clear or which you believe should be added, please send your comments to Technical Publications Coordinator, Terex Cranes, 106 12th Street SE, Waverly, Iowa 50677; or contact us by telephone at (319) 352-3920.

Thank you!

THIS SYMBOL MEANS YOUR SAFETY IS INVOLVED! READ, UNDERSTAND, AND FOLLOW ALL DANGER, WARNING, AND CAUTION DECALS ON YOUR MACHINE.

INTRODUCTION

SYMBOLS

The symbols below are used to inform the operator of important information concerning the operation of this unit.

⚠ DANGER

DANGER - Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

⚠ WARNING

WARNING - Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

⚠ CAUTION

CAUTION - Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

ATTENTION

ATTENTION - Indicates a situation which, if not avoided, may result in property or equipment damage.

SAFETY

⚠ WARNING

These are general safety rules, which must be followed. You are also required to read and understand the Operators Manual as there are instructions, which are more detailed specific to this machine.

HANDLING PERSONNEL

1. Cranes can only be used to lift people when it is the least hazardous way to do the job. (See OSHA 1926.550g, and ASME / ANSI B30.23.)

TRAINING AND KNOWLEDGE

1. Safety must always be the operators most important concern.
2. Do not operate this crane until you have been trained in its operation. This crane must only be operated by trained personnel, who have demonstrated their ability to do so safely.
3. Comply with the requirements of current Occupational Safety and Health Administration (OSHA) standards, the current American National Standards Institute (ANSI) B30.5 latest edition.
4. Read and Understand all Decals and Warnings.
5. Read and Understand the Rating Chart.
6. Know that the crane can safely lift each load before attempting to lift.

7. Operator must understand crane signals and take signals only from designated signal people; except the operator must obey the stop signal from anyone.

⚠ OPERATOR’S RESPONSIBILITIES

1. Read and understand the Operator's Manual.
2. Make sure the machine is in proper order and that all operational aids and warning signals are functional before operating.
3. Keep the machine clean, including all instrumentation, windows, lights and other glazed surfaces.
4. Remove all oil, grease, mud, ice and snow from walking surfaces.
5. Store tools and other necessary items in the tool box.
6. Never lift a load without a Rating Chart Manual in the cab.
7. Know the load to be lifted.
8. Be alert, physically fit and free from the influences of alcohol, drugs or medications that might affect the operators eyesight, hearing, or reactions.
9. Keep people, equipment and material out of the work area.
10. Signal person must be used when the operators vision is blocked or working in hazardous areas such as power lines or people.
11. Keep a fully charged fire extinguisher and first aid kit in the cab at all times, and be familiar with how to use these items.
12. Know about movements of other machinery, trucks and personnel at the jobsite.
13. Never permit people on the machine platform while the machine is working.

14. Make sure everyone is in a safe place before moving the hook, boom, load or outriggers.

15. Start and stop movements smoothly and swing at speeds that will keep the load under control.

16. Keep at least two full wraps of wire rope on drum when operating.

17. Feet must be kept on the pedals while foot pedal brake locks are in use.

18. Use tag lines to keep loads under control.

19. Keep load close to ground.

20. Use shortest boom possible.

21. Never leave a running machine unattended or load suspended.

22. Always use outriggers in accordance with requirements of Load Rating Chart and operators manuals.

⚠ SIGNAL PERSON’S RESPONSIBILITY

1. Standard crane signals must be used, and understood.

2. Assist the operator in safe and efficient operation, without endangering people or property.

3. Have a clear understanding of the work to be done.

4. Signal people must place themselves where they can be clearly seen and where they can safely observe the entire operation.

⚠ RESPONSIBILITIES OF ALL CREW MEMBERS

1. Unsafe conditions or practices must be corrected.
2. Obey all warning signs.
3. Watch out for your safety and the safety of others.
4. Know and understand proper machine erection and rigging procedures.
5. Alert operator and signal person of dangers, such as power lines, unstable ground etc.

⚠ MANAGEMENT RESPONSIBILITY

1. Operator's must be competent, physically fit and if required licensed.
2. Operator, signal people and riggers must be trained in correct crane operation and use.
3. Operator and Signal people must know standard crane signals.
4. Have a supervisor at job site to be responsible for job safety.
5. Crew members given specific safety responsibilities and instructed to report any unsafe conditions to supervisor.
6. Supply the weight on the load to be lifted to the operator.
7. Verify that all crew members are familiar with OSHA, ANSI B30.5 requirements as well as instructions in manuals.

⚠ PLANNING THE JOB

1. Have a clear understanding of work to be done.
2. Consider all dangers at jobsite.
3. Know what crew members are needed?
4. Assign responsibilities.
5. Know the weight of load to be lifted.
6. Determine lift radius, boom angle, and the rated lifting capacity of crane.
7. Establish how signal people will communicate with operator?
8. Utilize equipment which will do job safety.
9. Establish how equipment can be safety transported to job site?
10. Determine where gas lines, power lines, or structures are which must be moved.
11. Ensure that surface is strong enough to support machine and load.
12. Determine how load will be rigged.
13. Establish special safety precautions, if necessary.
14. Consider weather conditions.
15. Keep unnecessary people and equipment away from work place.
16. Position machine to use shortest boom and radius possible.

⚠ OPERATOR'S SAFETY CHECK

1. Safety related items must be in place.
2. Check machine log book, to see if periodic maintenance and inspections have been performed.
3. Ensure that necessary repairs have been completed.
4. Inspect wire rope for damage (kinks, broken wires etc.)
5. Be sure no unauthorized field modifications have been made.
6. Check for air and hydraulic oil leaks.
7. Check control positions before starting engine.
8. After starting engine, check all gauges and indicators for proper readings.
9. Test all controls.
10. Check brakes and clutches.
11. Check load brakes by lifting a load a few inches off the ground and holding it.

⚠ OPERATOR AIDS CHECK

Ensure that the listed items are in place and operational.

1. Boom hoist upper angle limit switch. (Lattice Boom).
2. Boom angle indicator.
3. Backup Alarms.
4. Anti-Two Block devices.
5. Overload Protection, Load Indicators, Rated Capacity Limiters

⚠ OPERATION OVERLOAD PREVENTION

1. Know the weight of the load.

2. Load radius will increase when the load is lifted. Reduce radius at start of lift to allow for this.

3. Know the weight of hook, and rigging.

4. Know boom length, jib length, parts of line and operating area.

5. Use next lower rated capacity when working at boom lengths or radius between the figures on the rated lifting capacity chart.

6. Never lift a load without knowing whether it is within the rated capacity.

7. Never operate with anything other than recommended counterweight.

   Unauthorized reduction or additions of counterweight constitute a safety hazard.

8. Do not lift loads if winds create a hazard. Lower the boom if necessary. See the Rating Chart Manual for possible restrictions.

9. Avoid side loading.

10. Never let the load or any other object strike the boom.

11. Release load slowly, be sure boom never tightens against back stops. (Lattice Boom).

12. Place the boom point directly above the load when lifting.

13. Be sure loads are freely suspended.

⚠ OPERATION SETUP

1. Be sure the load bearing surface is strong enough to support the machine and load.

2. Be sure cranes are level, check frequently and relevel when necessary.

3. Stay away from rotating cranes, erect barricades to keep people away. Make sure these area's are clear before swinging.

⚠ POWER LINE SAFETY

1. Determine whether there are power lines in the area before starting any job. Only operate around power lines in accordance with Federal, State and Local Regulations as well as ANSI B30.5 latest edition.

2. Never remove materials from under powerlines with a crane if the boom or machine is capable of contacting them.

3. No part of crane or load must come in contact with, or violate the minimum allowable clearance required for operation of crane dear electrical lines.

4. Should contact occur stay on crane until the boom is cleared or until the current is turned off.

5. If in contact keep all personnel off the crane. If you must leave the crane, JUMP, DO NOT STEP OFF, leave area by jumping with feet together.

6. Use a signal person when working around power lines.

1. Always wait until machine has stopped before getting on and off equipment. Do not jump on or off.
2. Do not use controls and steering wheel as hand holds.
3. Keep the machine clean and dry.
4. Replace all broken ladders.
5. Keep non-slip surfaces in good condition.

⚠ TRAVEL

1. Care must be taken when cranes are driven (traveled) whether on or off the job site.
2. Watch for people, power lines, low or narrow clearance, bridge or road load limits, steep hills or uneven terrain.
3. Position boom in line with the direction of travel.
4. Inflate tires to specified pressure.
5. Travel slowly and avoid sudden stops and starts.
6. It is recommended that the seat belt be used during transit and travel.
7. Make sure travel surface can support weight of machine and load.
8. Always set parking brakes when parking machine.

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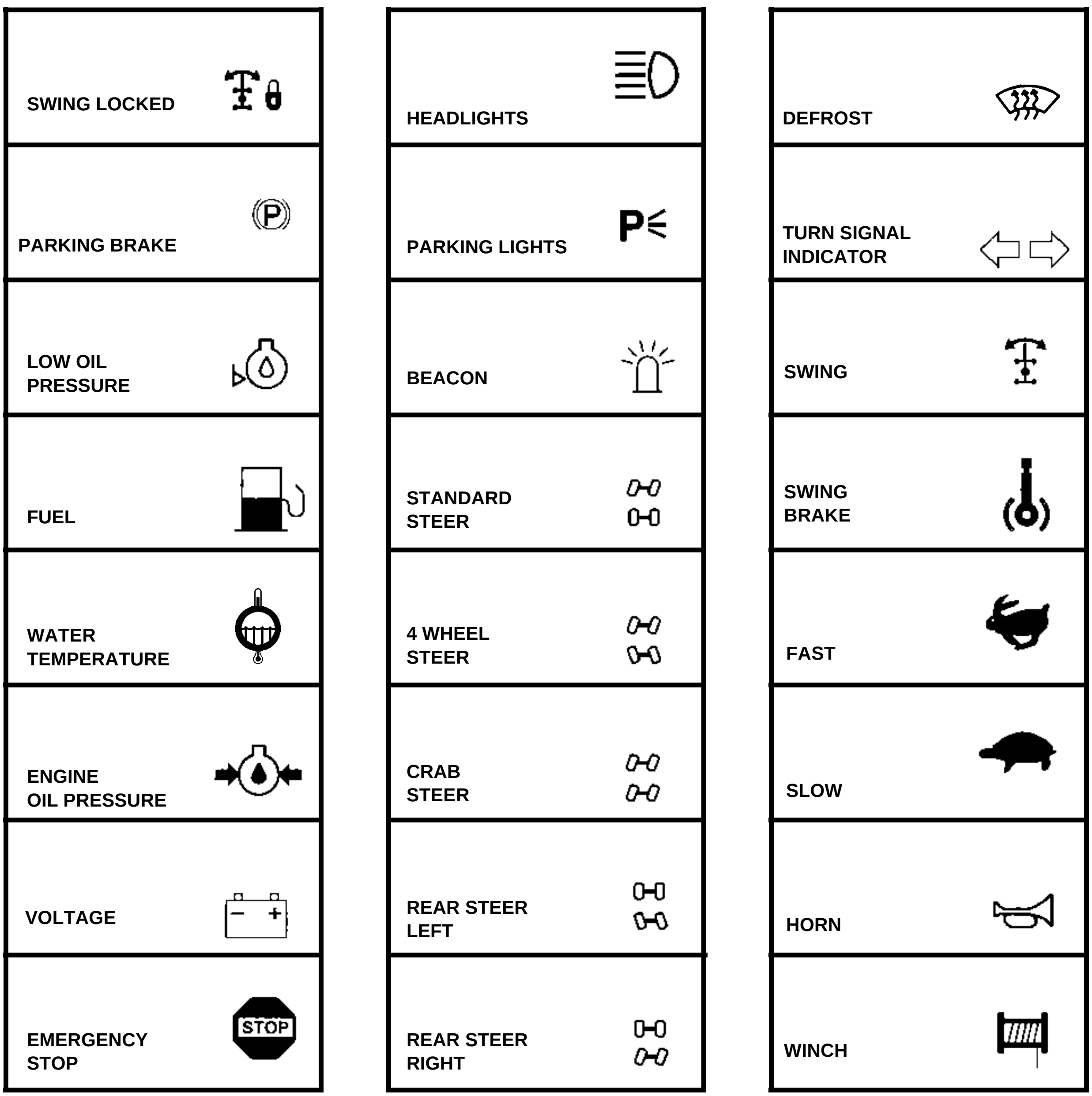
SUBJECT **PAGE**

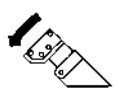
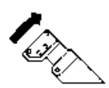
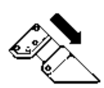
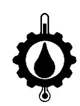
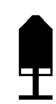
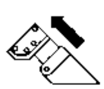
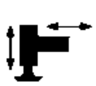
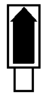
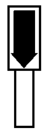
This section is intended to familiarize the operator with the controls and instruments provided for the operation of this machine. It should be emphasized, however, that merely knowing the controls is inadequate preparation for operating hydraulic cranes. Do not attempt to operate the machine until the other sections of this manual have been covered. Sections 1 and 3 are especially important with respect to machine operation.

Diagrams of the various carrier and upper controls are illustrated on the following pages. A list of these controls and instruments are shown opposite each illustration. More detailed explanations of each control or instrument follow in the same order as they appear in the number key.

UNIVERSAL SYMBOL IDENTIFICATION



UNIVERSAL SYMBOL IDENTIFICATION (cont.)

AIR PRESSURE 	IGNITION 	WINDSHIELD WASHER 
SWING LEFT 	ELECTRICAL ACCESSORIES ON 	WINDSHIELD WIPER 
SWING RIGHT 	ELECTRICAL SYSTEM OFF 	HAZARD LIGHTS 
BOOM DOWN 	ELECTRICAL SYSTEM ON 	AXLE ENGAGE / RANGE SHIFT 
BOOM UP 	IGNITION ON 	AXLE DISENGAGE / RANGE SHIFT 
BOOM IN 	TRANSMISSION TEMPERATURE 	ENGINE QUICK START 
BOOM OUT 	TRANSMISSION PRESSURE 	
OUTRIGGER SELECT 	HEATER/AC HEAT 	
OUTRIGGER RETRACT 	HEATER/AC AC 	
OUTRIGGER EXTEND 	HEATER/AC FAN 	

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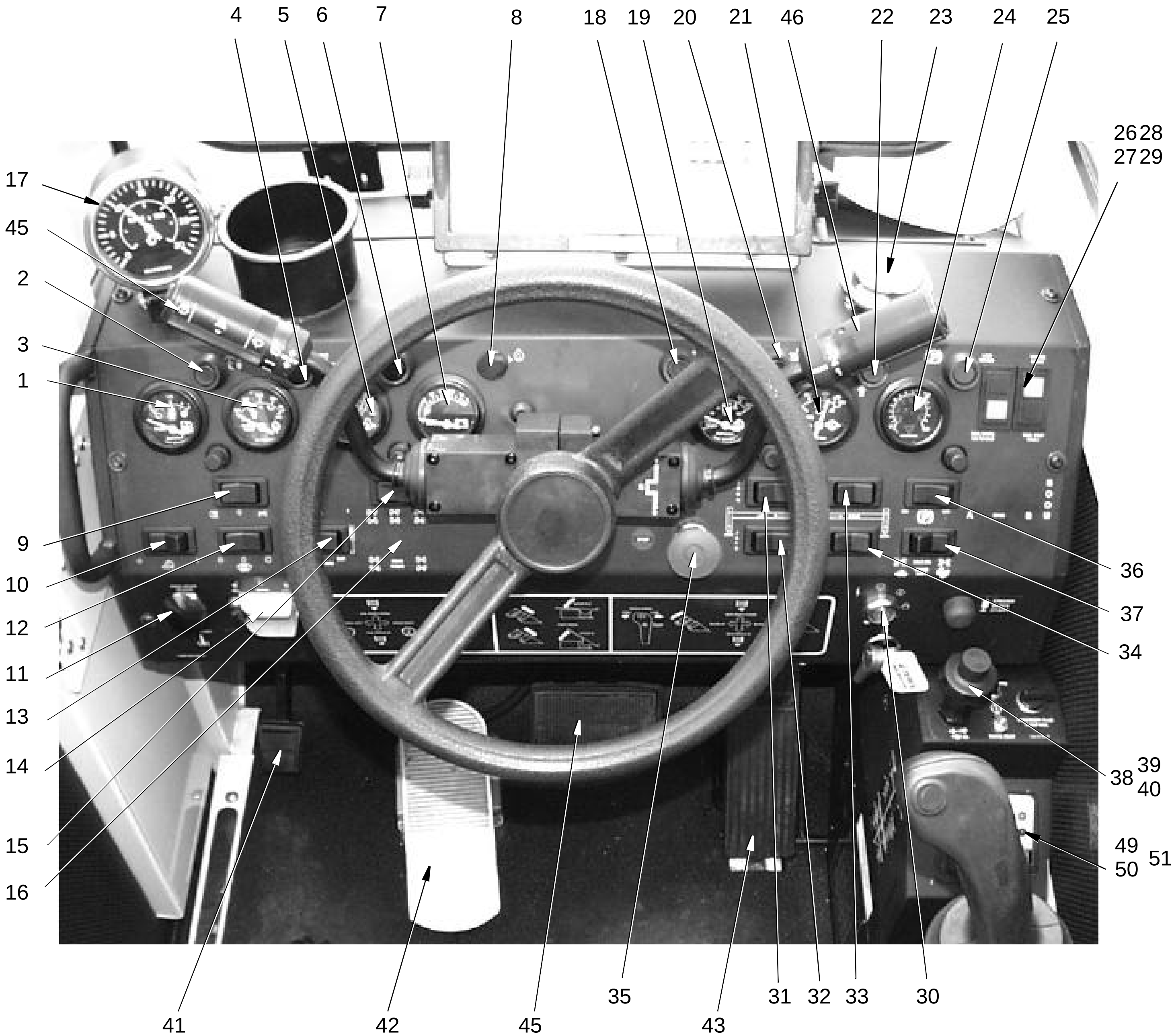
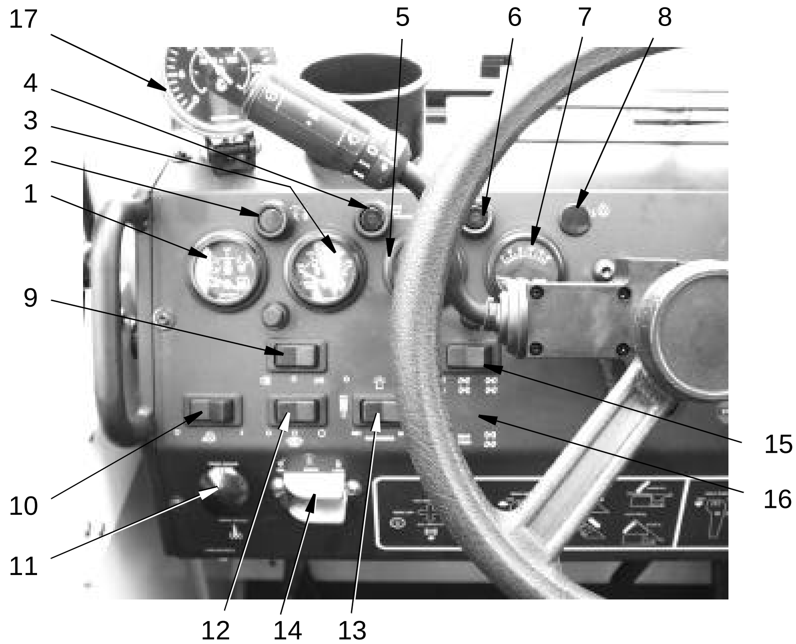
UPPER CONTROLS & INSTRUMENTS



UPPER CONTROLS & INSTRUMENTS KEY

1. FUEL GAUGE
2. SWING LOCKED INDICATOR
3. ENGINE COOLANT TEMPERATURE GAUGE
4. REAR AXLE CENTERED INDICATOR
5. ENGINE OIL PRESSURE GAUGE
6. LEFT TURN SIGNAL INDICATOR
7. VOLTMETER
8. LOW OIL PRESSURE INDICATOR
9. DASH LIGHT SWITCH
10. WORK LIGHT SWITCH
11. SWING BRAKE RELEASE
12. DEFROSTER FAN SWITCH
13. OUTRIGGER EXTEND/RETRACT MASTER
14. SWING LOCK SWITCH
15. STEERING SWITCH
16. REAR STEER SWITCH
17. TACHOMETER
18. WAIT TO START LIGHT
19. TRANSMISSION TEMPERATURE
20. RIGHT TURN SIGNAL INDICATOR
21. TRANSMISSION OIL PRESSURE
22. LOW AIR WARNING LIGHT
23. BUBBLE LEVEL
24. AIR PRESSURE GAUGE
25. PARK BRAKE INDICATOR
26. LOW WATER INDICATOR
27. ENGINE WARNING INDICATOR
28. ENGINE DIAGNOSTIC INDICATOR
29. ENGINE STOP / FAULT INDICATOR
30. IGNITION SWITCH
31. LEFT FRONT OUTRIGGER SWITCH
32. LEFT REAR OUTRIGGER SWITCH
33. RIGHT FRONT OUTRIGGER SWITCH
34. RIGHT REAR OUTRIGGER SWITCH
35. EMERGENCY STOP
36. PARKING BRAKE SWITCH
37. AXLE DISENGAGE / RANGE SHIFT
38. HAND THROTTLE
39. SWING BEARING GREASE FITTING
40. SWING GEAR GREASE FITTING
41. SWING BRAKE
42. BOOM EXTEND RETRACT PEDAL
43. ACCELERATOR
44. BRAKE PEDAL
45. WIPER CONTROL
46. GEAR SELECTOR
47. SWING / AUX WINCH CONTROL / HORN
    (See Page 2-11)
48. BOOM HOIST / MAIN WINCH CONTROL / HORN
    (See Page 2-11)
49. CAB FAN SPEED
50. CAB HEAT/AC SELECTOR
51. CAB HEATER TEMPERATURE
52. FIRE EXTINGUISHER
    (See Page 2-12)

UPPER CONTROLS & INSTRUMENTS



1. **FUEL GAUGE -** Graduated in quarters of full tank.

2. **SWING LOCKED INDICATOR -** Indicates swing lock is engaged.

3. **ENGINE COOLANT TEMPERATURE GAUGE -** Measures engine coolant temperature.

4. **REAR AXLE CENTERED INDICATOR -** Indicates rear axle is centered.

5. **ENGINE OIL PRESSURE GAUGE -** Measures engine oil pressure.

6. **LEFT TURN SIGNAL INDICATOR**

7. **VOLTMETER -** Indicates battery or alternator condition.

8. **LOW OIL PRESSURE INDICATOR -** Indicates engine oil pressure is too low.

9. **DASH LIGHT SWITCH -** Push left for dash lights only, push right for dash lights and head lights.

10. **WORK LIGHT SWITCH -** Push right to turn on work light.

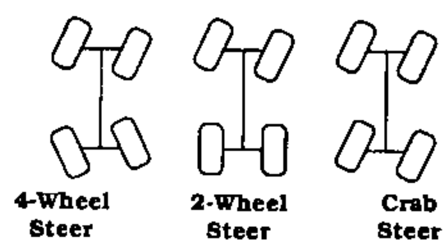
11. **SWING BRAKE PEDAL RATCHET RELEASE -** Pull and lock to permit operation of the pedal. Release to allow pedal to be locked in applied position.

12. **DEFROSTER FAN SWITCH -** Push left for “LO”, center for “OFF”, right for “HI”.

13. **OUTRIGGER EXTEND/RETRACT MASTER SWITCH -** This switch is used in conduction with outrigger switches (31-34) to extend and retract the outrigger beams and jacks. Push left to retract and right to extend.

14. **SWING LOCK SWITCH -** Push right to engage swing lock, left to disengage.

15. **STEERING SWITCH** - Provides the following:



⚠ CAUTION

Switch to crab or 4-wheel steering only when axles are centered. Otherwise, steering will be limited and may lock.

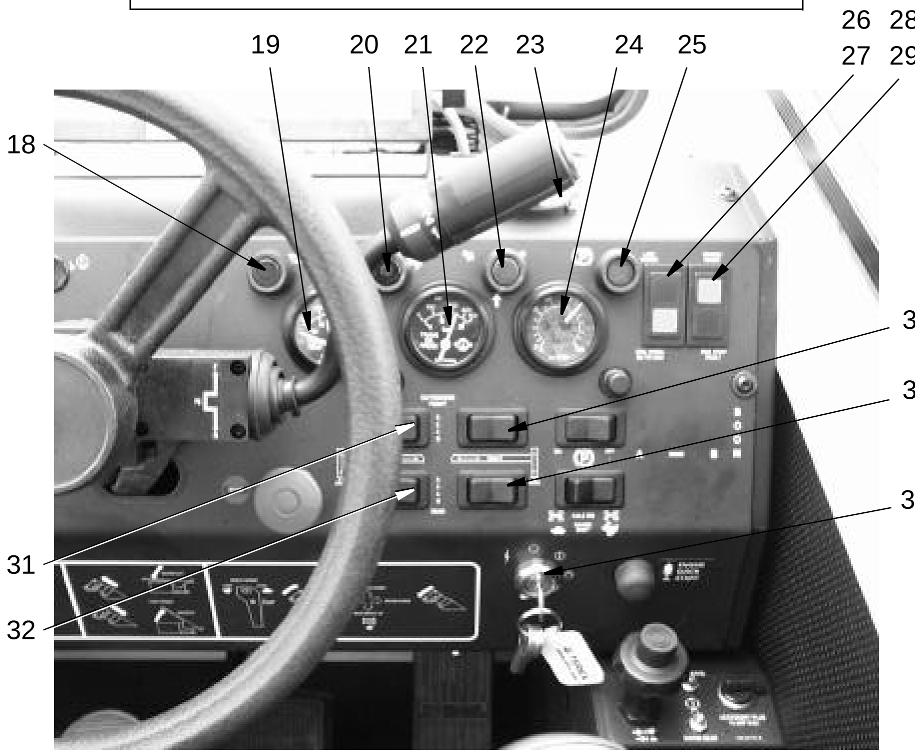
If wheels should become locked, switch to 2-wheel steer, turn front wheels, switch back to crab or 4-wheel steer and center wheels.

Exercise caution when the upper structure is not in the travel position as the steering will appear to be reversed when boom is over rear.

16. **REAR STEER SWITCH -** Push left to toggle rear wheels left, push right to toggle rear wheels right.

17. **TACHOMETER -** Indicates engine RPM.

UPPER CONTROLS & INSTRUMENTS



18. WAIT TO START LIGHT - Lights when key is in on position to indicate grid heater is activated. When heat reaches adequate temperature light will go out, then machine can be started.

19. TRANSMISSION TEMPERATURE GAUGE - Indicates transmission temperature.

20. RIGHT TURN SIGNAL

21. TRANSMISSION OIL PRESSURE GAUGE - Indicates transmission charge pressure. Normal range is 240 to 300 psi.

ATTENTION

Never drive the machine when the charge pressure is below 240 psi.

22. LOW AIR WARNING LIGHT & BUZZER - Will warn when pressure falls below 65 psi.

23. BUBBLE LEVEL - The machine must be leveled prior to lifting loads.

24. AIR PRESSURE GAUGE - 105 - 125 psi optimum operating pressure.

25. PARK BRAKE INDICATOR - Indicates parking brake is applied.

26. LOW WATER INDICATOR - Indicates engine coolant level is too low.

27. ENGINE WARNING INDICATOR - Lights and then flashes to indicate: coolant temperature high, oil pressure low, or coolant low condition. Lights to indicate a fault code is present in diagnostic mode.

28. ENGINE DIAGNOSTIC INDICATOR - Not used.

29. ENGINE STOP / FAULT INDICATOR - Lights to indicate engine must be shut down immediately. Flashes out fault codes in diagnostic mode.

30. IGNITION SWITCH - Turn left for all circuits except ignition. Hold right to activate starter. Right position for all circuits.

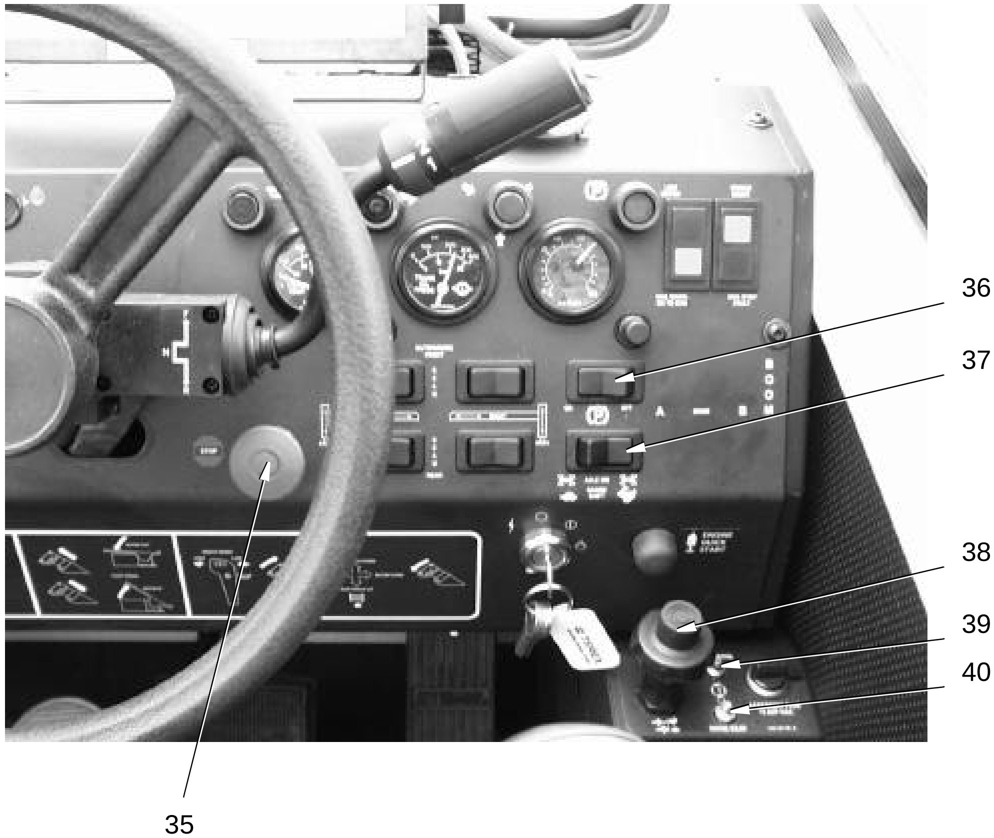
31. JACK SWITCH (LEFT FRONT) - Used in conjunction with switch (13), to extend/retract outrigger jack and beam.

32. JACK SWITCH (LEFT REAR) - Used in conjunction with switch (13), to extend/retract outrigger jack and beam.

33. JACK SWITCH (RIGHT FRONT) - Used in conjunction with switch (13), to extend/retract outrigger jack and beam.

34. JACK SWITCH (RIGHT REAR) - Used in conjunction with switch (13), to extend/retract outrigger jack and beam.

UPPER CONTROLS & INSTRUMENTS



35. EMERGENCY STOP - Push to stop engine in case of emergency. Pull to allow machine to be started again.

36. PARKING BRAKE SWITCH - Push right to activate parking brake.

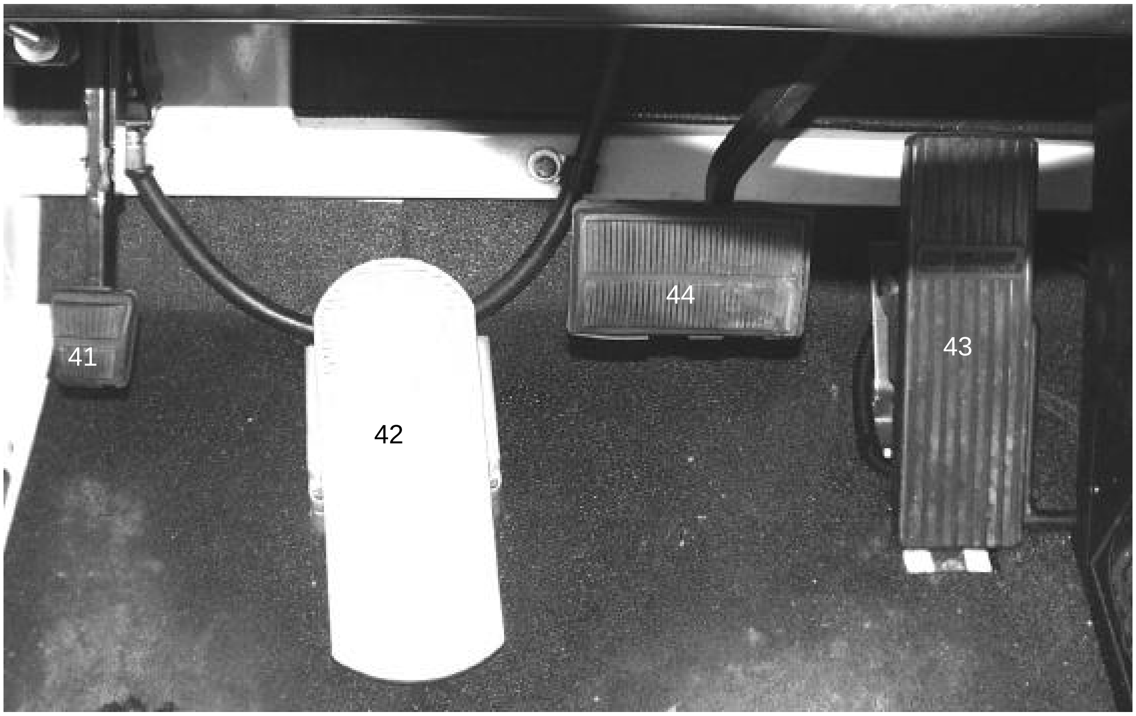
37. AXLE DISENGAGE / RANGE SHIFT - Push right to disengage front axles for high speed travel.

38. HAND THROTTLE - Holds engine throttle at an operator settable position. Place the accelerator (43) at approximate RPM. Push in button on hand throttle. Pull throttle up and release button to lock. Make fine adjustments to engine RPM by rotating the hand throttle clockwise to decrease RPM and counter-clockwise to increase RPM.

39. SWING BEARING GREASE FITTING - Inject bearing grease here.

40. SWING GEAR GREASE FITTING - Inject gear grease here.

UPPER CONTROLS & INSTRUMENTS



41. **SWING BRAKE** - Apply to prohibit boom from swinging

42. **BOOM EXTEND RETRACT PEDAL -** Tilt the pedal halfway forward to power-extend the boom. Tilt the pedal all the way forward for high speed (regenerative) extend. The boom extend will stop at the transition between power extend and high speed. In high speed extend the boom extend has minimal extend force. Tilt backward to retract boom.

43. **ACCELERATOR -** Push to increase engine RPM and release to decrease.

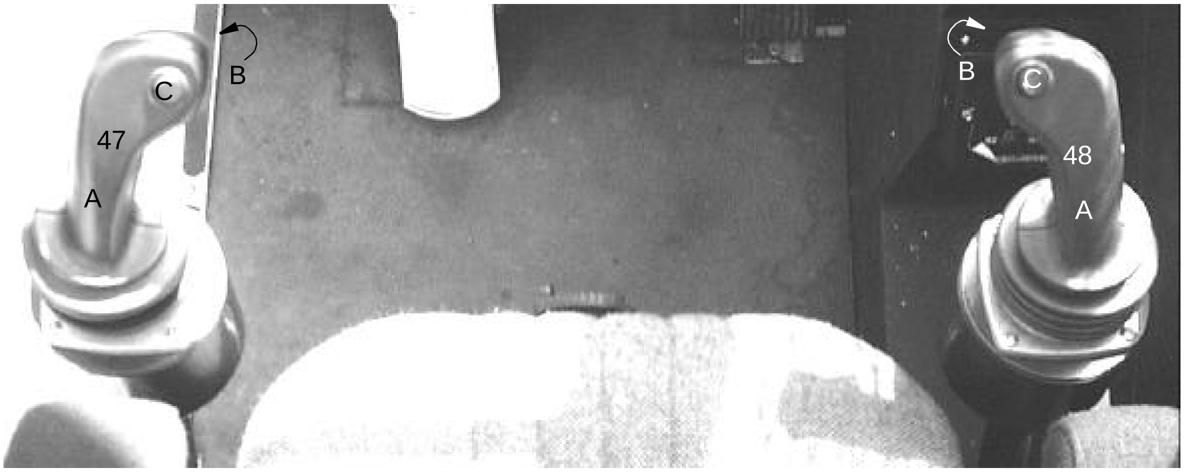
44. **BRAKE PEDAL -** Push to stop carrier movement.

UPPER CONTROLS & INSTRUMENTS

45. WIPER CONTROL - Use to control windshield wiper functions. Push up for right turn signal. Push down for left turn signal. Press button on end to dispense washer fluid onto window. Rotate for windshield wiper. Pull toward operator for hazard lights.

46. GEAR SELECTOR - Use to control transmission gear selection. Move up for forward, down for reverse. Rotate handle to select speed.

UPPER CONTROLS & INSTRUMENTS



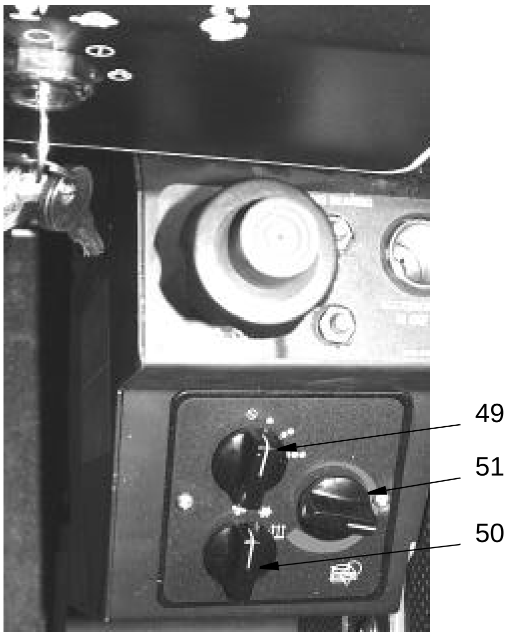
47. SWING/AUX WINCH CONTROL - Move joystick forward to pay out aux winch rope. Move joystick backward to take in aux winch rope. Move joystick left to swing boom left. Move joystick right to swing boom right.

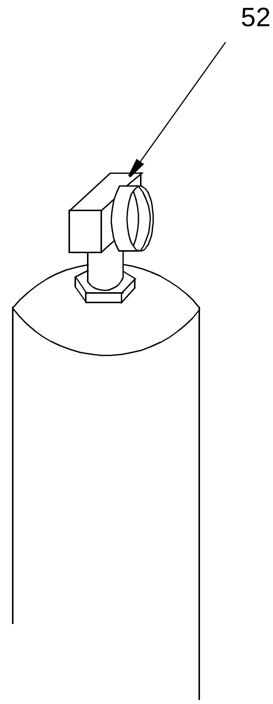
- 47A Aux Winch Rotation Indicator - Thumps to signal that rope is moving. (Located internally in handle)
- 47B Horn - Press to sound horn. (Located on underside of handle)
- 47C Hi-Speed Winch Switch - Press to toggle high speed winch.

48. BOOM HOIST/MAIN WINCH CONTROL - Move joystick forward to pay out main winch rope. Move joystick backward to take in main winch rope. Move joystick left to raise boom. Move joystick right to lower boom.

- 48A Main Winch Rotation Indicator - Thumps to signal that rope is moving. (Located internally in handle)
- 48B Horn - Press to sound horn. (Located on underside of handle)
- 48C Hi-Speed Winch Switch - Press to toggle high speed winch.

UPPER CONTROLS & INSTRUMENTS





49. CAB FAN SPEED - Turn to select blower fan speed.

50. CAB HEAT/AC SELECTOR - Turn to select heat or air conditioning.

51. CAB HEATER TEMPERATURE - Turn to adjust heating or cooling temperature.

52. FIRE EXTINGUISHER

INDEX

SECTION 3

PRE-START INSPECTION

The following items should be checked each day before start-up and the start of operations. Also see Section 4, “Daily Check.”

ENGINE OIL The level should be at the full mark.

COOLANT The coolant should be visible in the sight gage near the top of the radiator tank.

LEAKAGE Make a ground check below the machine for signs of leaks.

FUEL Engine fuel and propane/diesel for the upper unit heater should be adequate for sustained operations.

LUBRICATION Perform the daily lubrication as required in the Lubrication Recommendations.

HYDRAULIC SYSTEM Check hoses, tubes, components, reservoir sight gauge, valves, pumps, motors, connections, reservoir oil temperature, cylinder mounting bushings and pins.

LINES AND BLOCKS Inspect the hoist lines, hoist block, hook latch, and ball hook, as well as the crane attachment in general for readiness.

TIRES The tires should be checked for proper pressure before traveling the machine. The tires should only be checked when cold. Refer to the Tire Pressure Chart on the Load Rating Chart.

WHEEL NUTS Torque wheel nuts to 400-500 Ft. Lbs. Tighten daily during the first 50 miles of service on new units and any time the wheels have been removed. Tighten nuts alternately around the wheel.

GENERAL CONDITION Inspect the machine in general for wear, leakage and damage.

AIR TANKS Open the air tank drain cocks to blow out moisture and sediment.

TRANSMISSION OIL Check the transmission oil level. The level should be visible in the sight gage located on the lower part of the transmission case on the left side of the machine.

FUEL FILTER Water should be drained from the water separator on a Daily Basis. Both the water separator and fuel filters have drain cocks located at the bottom of each. Separator and filters are located in the engine compartment on the right side of the machine. For further information, See Section 4, “Engine Maintenance Checks”.

EMERGENCY STOP The emergency stop button is located on the lower part of the dash to the right of the steering column in the operator’s cab. In an emergency, this button can be pushed in to stop all crane functions including engine operation. You must pull the button out before you can resume normal operation of the crane.

SAFETY EQUIPMENT Check the safety equipment, including all lights, brakes and hazard warning devices.

OPERATOR AIDS

ANTI-TWO BLOCK SYSTEM Inspect all anti-two block switches found on boom, jib and auxiliary sheave heads for damage. Check the freedom of counterweight attached to these switches; and also, that counterweight is attached around correct line of hoisting cable in the proper manner. Inspect all electrical connections and wires as well as the entire length of cable attached to the cable reel and it's connections for evidence of excessive wear, damage or improper installation. Check spring loaded cable reel for proper tension and to insure that reel is free to rotate. Verify visual and audible warning devices by lifting each of the counterweights.

NOTE: A warning light will appear on the dash mounted panel and an audible signal will be heard when switch is in ON position.

RATED CAPACITY INDICATOR

The RCI will indicate an overload condition with an audible alarm and the exterior RCI lamp above the cab door will flash. All boom functions will be disabled except boom retract and winch down. Move the load into an acceptable condition to stop alarms and continue normal crane operation. (See RCI Section for further details.)

3RD WRAP

Winch down function will be disabled when less than 3 wraps of rope are available on the winch. You must retract boom or winch up.

OPERATOR'S ARMREST

When Operator's left arm rest is raised, all functions are disabled. Lower arm rest to resume normal crane operation.

STARTING THE ENGINE

Once the pre-start inspection has been completed, the engine may be started. At ambient temperatures over 32 deg. F. on Cummins Engines, follow the starting procedure below:

1. Open the governor to the idle position.
2. Move the transmission shift lever to the neutral position.
3. Put the parking brake switch in the “ON” position.
4. Turn the ignition switch to the “ON” position.
5. Turn the ignition switch to the “START” position to start the engine.

Release the ignition switch key as soon as the engine starts. If the engine stalls during the start-up procedure, allow the engine to stop revolving before re-engaging the starter.

Do not engage the starter motor for more than 30 seconds at a time. Should the engine fail to start within 30 seconds, allow the starter motor to cool for 2 minutes before attempting to start the engine again.

Once the engine is started, check the gauges for proper readings. If the gauges do not register normal readings, stop the engine and determine the cause. Avoid full Throttle operation when the engine is cold. Always allow the engine to reach normal operating temperature before commencing operations.

NOTE: On machines equipped with a turbocharged engine, the oil pressure gauge MUST register 10 psi (60 kpa) at idle speed to ensure full lubrication of turbocharger.

OPERATING THE ENGINE

If the engine oil pressure gauge does not register normal operating pressure within 30 seconds of starting, shut down the engine, determine the cause and effect repairs before re-starting the engine.

When the engine reaches operating temperature, operations may begin. While the engine is running, check the gauges at frequent intervals and be alert for any abnormal engine sounds or faulty engine performance.

NOTE: Most alternators have a speed which must be exceeded to turn them on. It is recommended that the engine be speeded up to at least 2/3 speed after start-up and before any extended periods of low rpm operation to maintain battery charge.

When idling for extended periods, maintain an idle speed sufficient to prevent the battery from being discharged. Keeping the battery in a fully charged state is important both for starting the engine and for powering the emergency steering pump.

Throttle down to half speed or slower with no load for at least 5 minutes before stopping. This gives the engine a chance to cool off gradually before it is stopped.

NOTE: This cool down period is extremely critical on machines equipped with turbocharged engines due to the excessive build up of heat during normal load operations.

Consult the engine manufacturer's manual for further operating instructions.

COLD WEATHER STARTING

At ambient temperatures below 32 deg. F. on all Cummins Engines, the "Quick-Start" device should be used before engaging the starter. Push the "Quick-Start" button for three seconds, release it and engage the starter.

CAUTION

The handling and storage of "Quick-Start" should strictly conform to manufacturer's recommendations.

At very low temperatures, when the engine is dif- ficult to start and operator experience so indicates, follow the starting procedure outlined below:

1. Disengage the pumps.

2. Start the engine as described above, using the "Quick-Start" device. ALLOW THE ENGINE TO WARM UP. This is recommended so that optimum engine power is obtained at low speed for the protection of the hydraulic system.

ATTENTION

3. BE ALERT FOR SIGNS OF CAVITATION. The hydraulic oil provides lubrication for the pumps. When to heavy or stiff, it will not flow fast enough to meet pump demand and a vacuum or "cavitation" will be created. A "screaming" noise indicates inadequate pump lubrication, and, if allowed to continue for more than a short period, will result in serious damage to the pumps.

If cavitation noise is noticed, the hydraulic oil must be warmed by use of a reservoir immersion heater. When the reservoir is warm to the touch, the starting procedure may be continued. Refer to the lubrication chart for the recommended oil viscosity for the winter season.

4. Stop engine.

5. Re-engage pumps.

6. Restart engine. Be alert for signs of pump cavitation as described in (3) above. Increase engine speed GRADUALLY, allowing sufficient time to warm the system before commencing operation.

JUMP STARTING AN ENGINE WITH BOOSTER CABLES

Position the vehicle with the booster battery adjacent to the vehicle with the discharged battery so that booster cables can be connected easily to the batteries in both vehicles. Make certain vehicles do not touch each other.

1. On both vehicles turn off all electrical loads. Set the parking brake. Place transmission in “PARK”.

2. Determine whether the discharge battery has the negative (-) or positive (+) terminal connected to ground. The ground lead is connected to the engine block, frame, or some other good metallic ground. The battery terminal connected to the starter relay is the one which is not grounded.

3. Be sure that the vent caps are tight and level on both batteries. Place a damp cloth over the vent caps of each battery making certain it is clear of fan blades, belts and other moving parts.

The following steps must be performed in se- quence.

4. On a negative grounded system, connect both ends of one cable to positive (+) terminals of each battery.

5. Connect one end of the other cable to negative (-) terminal of the booster battery.

6. Connect other end of cable, away from bat- tery, to engine block, frame or some other good metallic ground, except carburetor or tubing on vehicle with discharged battery.

7. Make certain that all cables are clear of fan blades, belts and other moving parts of both engines and be sure everyone is standing away from vehicles. Then start the engine with the booster battery. Wait a few minutes, then at tempt to start the engine of the vehicle with the discharged battery.

8. After starting, allow the engine to return to idle speed and remove the cable connection at the engine block or good metallic ground. Then remove the other end of the same cable from the booster battery.

⚠ WARNING

WARNING - BATTERIES PRODUCE EXPLOSIVE GASES. These instructions are designed to minimize the explosion hazard. Keep sparks, flames, cigarettes, etc. away from batteries at all times - protect eyes at all times - do not lean over batteries during this operation.

Both batteries should be of the same voltage.

VEHICULAR OPERATION

The Rough Terrain Crane is capable of both off road and limited on-road travel. The kind of travel undertaken will determine how the carrier is operated.

Before moving the Before moving the crane, either around the work site or between sites, carefully consider the terrain type, road conditions and any hazards likely to be encountered enroute. Think the move through in advance and carry it out safely.

PRE-MOVE CHECK LIST Before moving the crane to and from job sites, make sure the following safety checks have been made:

NOTE: When properly adjusted the parking brake will hold this machine on a 30% grade, if the tires have adequate traction. It is recommended that when parked on a grade that the wheels be chocked.

1. Lock the upperstructure swing brake. Engage the swing lock.

2. Secure hook block to the bumper loop. If this is impractical, pull the two block system counterweight up to within approximately 1” of the load sheaves, or until block lightly contacts boom head. On machines equipped with control system disconnects, use override switch. Failure to pull the hook block up to the head when traveling, or to secure it to the bumper ring, will result in excessive swinging of the hook block and possible damage to crane.

CAUTION

Continuing to pull the block up after contact has been made may result in damage to the boom head, sheaves and anti-two block switch.

3. Check hydraulic outrigger beam retaining pins.

4. Disconnect the main pump if the crane is to be driven more than approximately 2 miles.

5. Shift into high range (two wheel drive).

6. Check the tires for proper inflation pressure as indicated on the “Crane Load Chart”.

7. Check that the rear wheels are centered and switch to 2-wheel steer.

8. Adjust the seat and mirrors for clear vision to the rear.

9. Check that the transmission oil pressure is within the normal operating range of 240 to 300 psi with 180-200° F oil temperature and engine at idle. Colder oil and higher RPM may create pressures over 300 psi. Low pressure may indicate a worn charge pump, clogged filter, or low oil level.

CAUTION

Never move the carrier if the transmission oil pressure is below 240 psi. Low pressure will cause transmission slippage and consequent premature failure of the clutch packs.

MOVING THE CRANE TO A JOB SITE The procedure for moving a crane is as follows:

1. Start the engine, following the procedure given in the topic “Starting the Engine”.

2. Allow air pressure build-up.

3. Apply the swing brake.

4. Apply the swing lock.

5. Apply the Service Brake.

6. Release the Parking Brake.

7. Select the desired transmission range.

Good judgement in the selection of gear range and route of travel is essential when operating off the road.

Though designed primarily for use in off-road conditions, there may be instances when highway travel is necessary. In such instances, the crane is subject to the same regulations which govern the operation of other heavy equipment on public roads. Adequate lighting, flares, flags and safety equipment should be on the cranes at all times.

ATTENTION

When operating on hard surfaces, use high range F4 thru F6 two-wheel drive only.Failure to do so may result in severe drive line “wind-up” and component failure.

The operator may start from rest in either forward or reverse in F4 or F2.

ATTENTION

In addition to conditions of terrain, gear selection while traveling is also determined by transmission temperature. Normal operating temperature is 160 to 200 deg. F. If the transmission temperature rises above 250 deg. F. (121.1 deg. C.) while traveling, the crane must be stopped and allowed to cool. Shift to neutral and run the engine at 1000-1200 rpm. The temperature should drop rapidly to the engine coolant temperature. If the temperature does not drop, trouble is indicated, and should be determined before moving again. Overheating generally occurs due to working in too high a gear ratio. **DO NOT SHUT OFF THE ENGINE WHEN THE TRANSMISSION IS OVERHEATING**.

ATTENTION

NEVER SHIFT BETWEEN FORWARD AND REVERSE WHILE THE CRANE IS IN MOTION.

Full power shifts under load may be made with- out endangering the transmission or drive components. However, downshifts should not be made when the vehicle speed exceeds the maximum speed of the next lower range. Downshifting at excessive speeds will overspeed the drive train components with possible resultant damage to the drive shafts.

Do not travel for extended periods at wide open throttle.
Four wheel drive engagement is accomplished by a solenoid shifted coupling in the transmissions. In the ranges F1 thru F3 and R2 and R3.

ATTENTION

Observe the restrictions given in the following chart during on-the-road operation. Maximum permissible running intervals are given in terms of miles and hours of travel time. Stop the crane when either limit has been reached (whichever comes first) and allow the crane to cool for the period indicated.

TIRE SIZE	29:50 X 25 - 28PR	
STATIONARY PRESSURE (PSI)	81	
CREEP PRESSURE (PSI)	81	
2 1/2 MPH PRESSURE (PSI)	65	
TRAVEL PRESSURE (PSI)	55	
RUNNING INTERVAL	4 HRS	2 HRS
COOLING PERIOD	1 HR	30 MIN

6. Stop the engine.

Before stopping the engine, put the transmission in neutral, and reduce the engine speed.

Always idle the engine for at least 5 minutes before stopping it. This gives the engine a chance to cool down and prevents overheating which can be caused by localized hot spots in the engine. The idle speed must be high enough to charge the battery but not higher than half speed. This cool down period is extremely critical on machines equipped with a turbocharged engine.

After several minutes at idle, the engine may be shut off by pushing the engine stop button. Turn the ignition switch to the OFF position after the engine has stopped.

VEHICLE TOWING If the vehicle is to be towed, it wil be necessary to run the engine at idle speed to lubricate the transmission clutches. If the engine cannot be run, towing must be limited to 3 mph and and one mile (max. total). If exceeded drive lines must be disconnected, tow at 20 mph max.

TRAVELING AROUND THE JOB SITE

CAUTION

When traveling around a job site, it is very important that the crane operator is very aware of what is happening with the crane as well as with other vehicles and personnel on the job site. The crane operator should observe the following rules as well as good common sense while moving a crane around a job site.

NOTE: See the "ON TIRES LIFTS" instructions found later in this section for instructions on moving the crane with a load.

- Carry the boom over the front only.

- Lock the swing brake and swing lock.

- Secure the hook block or ball to the bumper loop or raise the hook block or ball close to the boom head sheaves before moving.

- Make sure all outriggers are completely retracted before moving the crane.

- Do not travel with boom above horizontal unless the surface is firm, level and free of bumps and potholes.

- Watch for overhead obstructions such as trees, power lines, or bridges.

- If the terrain is rough or uneven it may be necessary to travel at a reduced speed to prevent instability or damage to the crane.

- Operating on steep grades requires caution because the oil in the engine or transmission will move to one side of the engine or transmission. As a result, the engine or transmission may not be fully lubricated which could damage the engine or transmission.

- The operator must be very careful on steep side slopes to avoid tipping the crane.

NOTE: This machine can travel on 15° side slopes which have a firm level prepared surface. Due to variations in surface, tire pressure, bumps, potholes, etc., we recommend that travel on side slopes be limited to 5° and that the boom be horizontal or below.

MAKING A TYPICAL LIFT

LIFT PROCEDURE In making lifts, the operator must successfully coordinate several crane functions. These include the boom raise/lower, boom extend/retract, load hoist/lower and swing functions. Although experienced operators tend to operate two or more of these functions simultaneously, the lift procedure can be broken down into the following sequence of operations.

OUTRIGGERS Set the outriggers as follows before initiating any lifting operations:

1. Remove the outrigger beam retaining pins.

2. To set the four(4) outriggers evenly, operate switches to raise crane to a level position. When level, retract jacks (together) at one end of crane an inch or so, and then extend them again (together) until crane is level. Then repeat this process for the opposite end of crane. This equalizes pressure in all four jacks. The controls for the out and down outriggers are mounted on the dash. The extend/retract master switch must be actuated before the appropriate function switches can be actuated to operate the outriggers.

CAUTION

This is a safety feature to prevent accidental actuation of the outriggers while the crane is in motion because the **STEERING IS NON-FUNCTIONAL WHILE THE OUTRIGGERS ARE BEING OPERATED.**

The outrigger beams **MUST BE FULLY EXTENDED**, and the crane leveled prior to extending the boom or lifting loads. To achieve this condition, the vertical jack cylinders should be extended only enough to lift the wheels off the ground.

CAUTION

FULL extension of the vertical jack cylinders should be avoided if not necessary to level crane and raise wheels clear of ground because oil expansion under extreme heat conditions can cause cylinder seal failure. Check to ensure that all beams are fully extended, swinging the upper if necessary to visually check that each beam reaches full extension. Level the crane using the bubble indicator to determine when a level condition is achieved. While operating the crane, frequently check and level the outriggers between lifts.

CAUTION

The operator must exercise sound judgment in positioning the outriggers. The outriggers should not be set near holes, on rocky ground or on extremely soft ground. Setting the outriggers in such locations may result in the crane tipping, causing personal injury or property damage. Where a firms footing or level ground is not otherwise available, it should be provided by substantial timbers, solid blocking, or other structural members sufficient to distribute the load so as not to exceed the safe bearing capacity of the underlying material, and to enable leveling of the crane.

Proper positioning of the outriggers is critically important to both the safety and effectiveness of craning operations.

Before making any crane lift, make sure the hook is properly engaged with the slings, or lifting device employed to make the lift. Be certain the hook latch is not supporting any of the load. Refer to the warning tag on the hook block.

⚠ WARNING

HOOK LATCH IS INTENDED TO RETAIN LOOSE SLINGS OR DEVICES UNDER SLACK CONDITIONS. IT IS NOT INTENDED TO BE AN ANTI-FOULING DEVICE, SO, CAUTION SHOULD BE USED TO PREVENT THE LATCH FROM SUPPORTING ANY OF THE LOAD. PERIODIC INSPECTION OF THE LATCH MUST BE MADE TO INSURE ITS PROPER OPERATING CONDITION

12400-2

3. Use the load rating chart attached to the crane to interpret the conditions and limitations that exist when making a lift with the crane. The determining factors are lifted load, radius, boom angle, working position, hoist line reeving, tire pressure, travel data, and use of a jib.

The examples given in this section pages 3-23 thru 3-29 are given for your interpretation of the terminology used on the chart. CAUTION: The load rating chart values used in the examples may not be the same as those on your load rating chart. Use the numbers from the chart attached to your crane whenever making lift calculation

⚠ CAUTION

Always consider, anticipate, and/or determine by trial the maximum amount of wire rope which will be payed off the winch drum to perform each different craning application of this crane. Be sure to provide for no less than two full wraps of wire rope remaining on the winch drum as specified in all applicable crane operating safety standards.

The increased possibility for inadequate wraps remaining on the winch drum occurs when operating with a higher number of parts of line than are required for the load being lifted, particularly at longer boom lengths and high boom angles.
Sufficient wire rope is initially provided to allow the hook block to reach ground level when reeved for the required parts of line indicated on the capacity chart for all given loads. Reeving with more parts of line than required may result in all of the wire rope being payed off the winch drum.

The intent of this caution is to prevent any possibility of either reverse winding of the rope on the winch drum, which could cause breakage of the winch rope, or of unseating the rope wedge in the winch drum, which could result in the uncontrolled fall of the hook block and load.

4. Raise the boom to the required angle, consulting the boom angle indicator which indicates boom angle relative to upperstructure.

The boom elevation is controlled by the right joystick. To RAISE the boom, slowly move the joystick LEFT. To LOWER the boom, slowly move the joystick RIGHT. Improved control is obtained by operating the engine at low speed while "metering" the controls. Always operate and release the controls slowly to minimize dynamic effects of the load. During a lift where precise control of the load is required, do not attempt to use more than one function at a time.

⚠ CAUTION

Always consider possible obstructions when varying boom height or length; not only those to the front of the cab at the time of the adjustment, but those which may be encountered during swings.

Think the swing through, considering all obstacles, before making the swing.

⚠ CAUTION

Never hold the controls in an "activated" position once the hoist/lower cylinder or extend/retract cylinders have reached the limits of their travel. This can cause overheating of the hydraulic oil if it is run over relief for prolonged periods.

5. Swing the boom over the load.

Upperstructure swing is controlled by the left joystick. To swing the upperstructure to the RIGHT, move the joystick RIGHT. To swing LEFT, move the joystick LEFT. Swing speed increases as the lever is moved further left or right. Swing speed also varies with the engine speed.

Before attempting to swing the upperstructure, make sure the swing brake is not set and the swing lock is not engaged. Be certain that no obstructions will block the swing.

When ready, try for a smooth, controlled, safe swing. The swing should be SLOW. Start the swing SLOWLY and allow the load to build up only enough momentum to carry it through to the point where it is to be lowered.

Begin slowing the swing in advance of the point where the load is to be lowered. Slow the swing GRADUALLY, so that it appears to “coast” to a stop over the desired spot.

GRADUALLY slow the swing by use of the joystick. First, move the joystick to the neutral position and then VERY SLOWLY into the opposite swing direction position as required to slow the swing.
Apply the swing brake, with the foot pedal, when the swing is stopped or when emergency situations dictate that the swing be terminated abruptly.

If properly executed, the load will hang motionless when the swing is terminated. If the load is oscillating, the swing was made too rapidly and/or stopped too abruptly.

⚠ CAUTION

Stopping the swing too abruptly will cause the load to oscillate and impose side loads on the boom. Because side loading can damage boom, ALWAYS START AND STOP SWINGS GRADUALLY.

⚠ CAUTION

Never pull sideways with a crane boom. Crane booms are not designed for excessive side pull and may collapse if subjected to excessive side loading.

6. Extend the boom to the desired length. Do not extend the boom further than necessary to perform the lift.

EXTEND the boom by tilting the extend-retract pedal FORWARD. RETRACT the boom by tilting the pedal BACK

⚠ CAUTION

While extending the boom, be sure to pay out sufficient hoist rope to prevent the hook block from being drawn up to the boom peak. The force of the extend cylinders can easily break the hoist line, dropping the hook block and load which may result in personal injury or property damage.

The boom extend function on this crane has two positions and two speeds. When the pedal is all the way forward, the regenerative mode provides increased speed. With the pedal approximately one half of the way forward, increased “PUSH” is available at reduced speed.

7. Lower the hook block to the load and fasten the hook.

Make certain the hook is properly engaged with the slings, or lifting device employed to make the lift. Be certain the hook latch is not supporting any of the load. Refer to warning tag on hook block.

Hoisting or lowering of the load with the winch is controlled by the right joystick. LOWER the load by moving the joystick FORWARD and RAISE the load by moving the joystick BACK. Improved control is obtained by operating the engine at low speed while “metering” the control. Always actuate and release this lever slowly to minimize dynamic effects of the load and to prevent “birds-nesting” of the cable on the winch drum.

To shift the winch into the high-speed mode the winch switch on the front of the joystick must be pressed. When slowing the winch, release switch to bring the load to a gradual stop. When the winch is operated in this mode, available line pull is reduced to approximately one half of the normal value. *NOTE: Two speed winch will operate in low speed mode ONLY if operating telescope, auxiliary winch or a clam bucket simultaneously with the winch functions.*

8. Lift the load to the desired height. For safety, lift the load no higher than necessary.

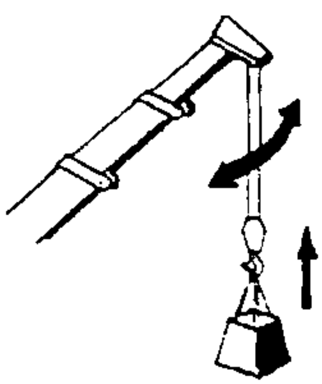
The crane is equipped with a two block system, in the event that the hook or block is raised beyond a safe position, a warning light appears on the dash and, if horn switch is activated, an audible warning will sound. Some cranes may be equipped with control disconnects which will prevent the winch from raising the load and the boom from extending or lowering. To continue crane operation, retract or raise the boom and/or lower the hook.

If the operator wishes to raise the hook block beyond the point at which the two block is activated, he may override the system by using the key switch *(shown in control and instrument sections).*

⚠ CAUTION

Continuing to pull the block up after contact has been made with the boom head may result in damage to boom head and sheaves or the cable may be broken causing the load to drop.

9. Swing and spot the load over the location where it is to be deposited.



10. Lower the load and unfasten the hook.

⚠ CAUTION

When spotting the load it may be necessary to alter the boom length or boom angle. In making these adjustments, the operator must guard against exceeding the rated load as determined by the load rating charts.
When operating a hydraulic crane, the operator should realize that hydraulic and structural competence, NOT TIPPING LOAD, is often the determinant of lifting capacity.

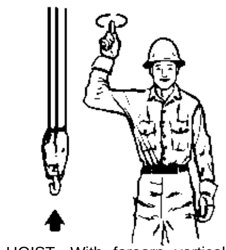
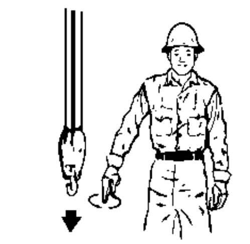
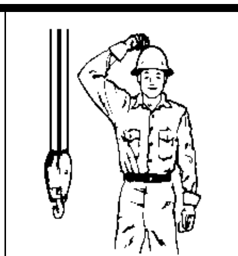
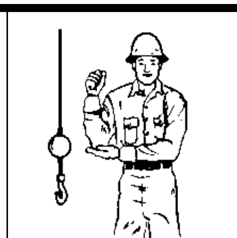
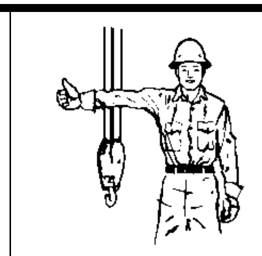
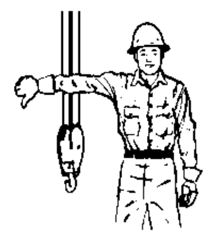
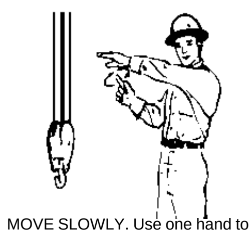
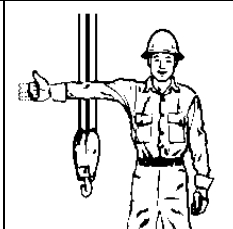
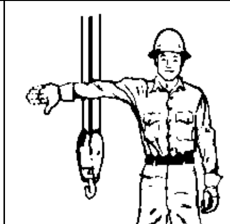
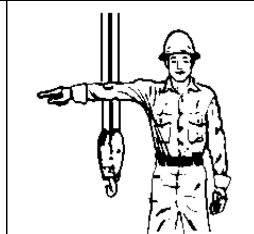
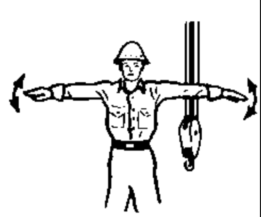
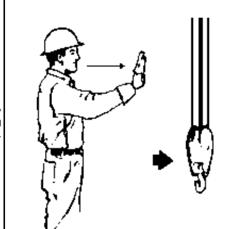
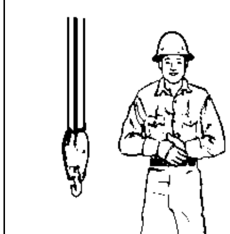
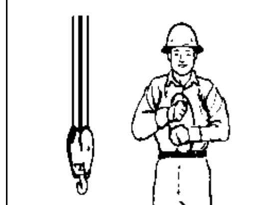
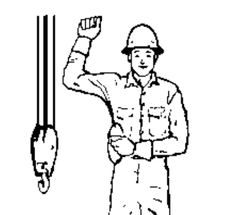
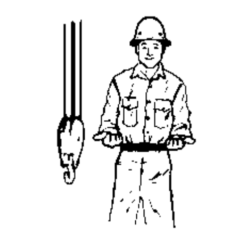
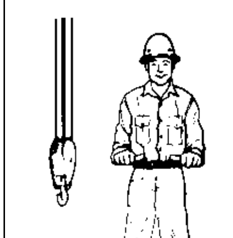
Therefore, THE OPERATOR MUST BE GUIDED SOLELY BY THE APPROPRIATE MANUFACTURER'S LOAD RATING CHART OR BY THE LOAD RATING PLATE MOUNTED ON THE CRANE when considering load weight. The manufacturer's rated loads must never be exceeded.

Cranes which are factory equipped with auxiliary winches may require additional counteweight if the auxiliary winch is removed. Refer to the capacity chart (load rating plate) for the required counterweight total.

⚠ CAUTION

When lowering light loads, be sure to maintain sufficient cable tension to prevent the cable from becoming loose on the cable drum. Loose cable can slip and then bind suddenly, causing "jerky" lowering and shock loading of the boom. Loose wraps may form loops which can be overlain when the cable is wound onto the winch drum. These conditions can result in personal injury or property damage.

CRANE HAND SIGNALS

 HOIST. With forearn vertical fore finger pointing up, move hand in small horizontal circle.	 LOWER. With arm extended downward forefinger pointing down, move hand in small circle.	 USE MAIN HOIST. Tap fist on head; then use regual signals.	 USE WHIPLINE. (Auxiliary Hoist) Tap elbow with one hand, then use regular signals.	 RAISE BOOM. Arm extended, fingers closed, thumb pointing upward.
 LOWER BOOM. Arm extended fingers closed, thumb pointing downward.	 MOVE SLOWLY. Use one hand to give any motion signal and place other hand motionless in front of hand gving the motion signal. (Hoist slowly shown as example.)	 RAISE THE BOOM AN LOWER THE LOAD. With arm extended, thumb pointing up, flex fingers in and out as load movement is desired.	 LOWER THE BOOM AND RAISE, THE LOAD With arm extended, thumb pointing dowm, flex fingers in and out as long as load movement is desired.	 SWING. Arm extended, point with finger in direction of swing of boom.
 STOP. Arm extended, palm down , move arm back and forth horizontally.	 EMERGENCY STOP. Both arms extended, plams down, move arms back and forth horizontally.	 TRAVEL. Arm extended forward, hand open and slightly raised, make pushiing motion in direction of travel.	 DOG EVERYTHING. Clasp hands in front of body.	 TRAVEL.(Both Tracks.) Use both fists in front of body, making a circular motion about each other, indicating direction of travel, forward or backward. (for land cranes only.)
 TRAVEL. (One Track) Lock the track on one side indicated by raised fist. Travel opposite track in direction indicated by circular motion of other fist, rotated in front of body. (land cranes only.)	 EXTEND BOOM. (Telescoping Booms.) Both fists in front of body with thumbs pointing outward.	 RETRACT BOOM. Telescoping Booms.) Both fists in front of body with thumbs pointing toward each other.	 EXTEND BOOM. (Telescoping Boom.) One Hand Signal. One fist in front of chest with thumb tapping chest.	 RETRACT BOOM. (Telescoping Boom.) One Hand Signal. One fist in front of chest, thumb pointing outward and heel of fist tapping chest.

⚠ CAUTION

KNOW THE CRANE SIGNALS! Poor communication between the operator and personnel directing lifts can result in property damage or personal injury.

"ON TIRES" LIFTS

Listed below are special precautions for "On Tires" lifts.

All crane load ratings are based on nonuse of the travel function while handling loads. However, cranes may be utilized for pick and carry operations. Traveling with suspended loads involves so many variables such as ground conditions, boom length, momentum in starting and stopping, etc., that it is impossible to devise a single standard rating procedure with any assurance of safety. For such operations the user must evaluate prevailing conditions and determine safe practices, exercising precautions, such as the following:

1.The boom shall be carried straight over the front of the crane.

2. Travel speed reduced to suit conditions.

3. Maintain specified tire pressures.

4. Avoid sudden starts and stops.

5.Provide tag or restraint lines to snub swinging of the load.

6. Keep the load as close to ground as possible.

7. Set the swing brake and swing lock.

8. Travel must be on a smooth level surface that is capable of supporting the weight of the loaded crane. The travel surface must also be free of holes or debris that can cause crane instability.

These precautions are necessary to prevent a "pendulum" effect of a swinging load. The results of this happening can cause a machine tip over.

CAUTION

Any variation from the above conditions will require the operator to consider the prevailing conditions and reduce the lift capacities accordingly.

CAUTION

Insufficient tire pressure reduces the "ON TIRES" capacity. Attempts to pick rated capacity without properly inflated tires may cause crane to tip and/or result in damage to tires and rims.

CAUTION

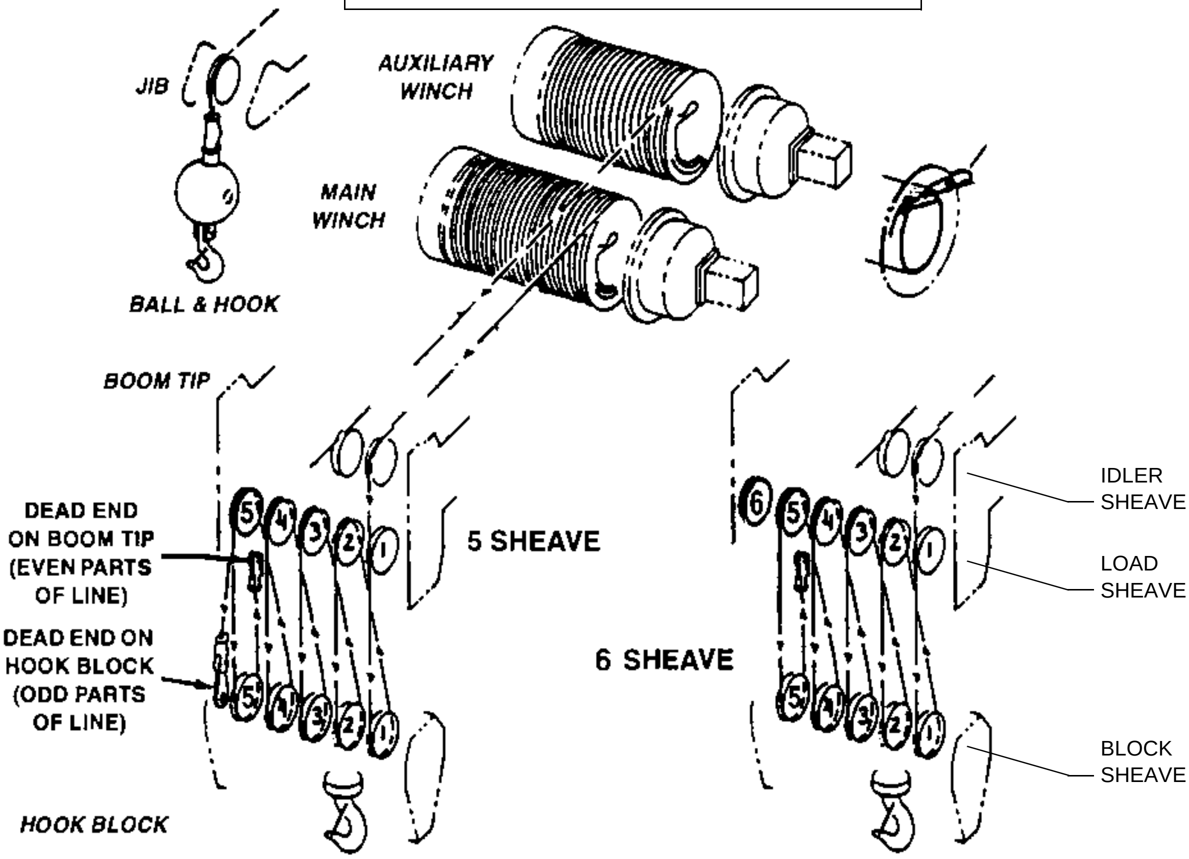
The axle lockout system should be bled and filled whenever oil seepage, dirt or oil is detected at the breather plug or on the rod.

Air in the axle lockout system decreases stability. Bleed and fill the system IMMEDIATELY whenever this condition occurs.

CAUTION

Excessive high hydraulic oil temperatures cause rapid deterioration of rubber components (hose, o-rings, etc.). A hydraulic oil cooler is required if high cyclic operations (clam, concrete bucket, unloading) are performed. If hydraulic reservoir temperature reaches 200 deg. F, reduce the duty cycle. Stop operations as required to prevent further increase in the hydraulic oil temperature.

HOIST LINE REEVING



SEE PAGES 3-13 AND 4-33 FOR CABLE AND SOCKET SPECIFICATIONS

PARTS OF LINE	BOOM HEAD (LOAD SHEAVE)	HOOK BLOCK (BLOCK SHEAVE)
1	1	D
2	1 D	3
3	1 5	3 D
4	1 4 D	1 4
5	1 2 3	2 4 D
6	1 2 4 D	2 3 4
7	1 2 3 4	2 3 4 D
8	1 2 3 4 D	1 2 3 4
9	1 2 3 4 5	1 2 3 4 D
10	1 2 3 4 5 D	1 2 3 4 5

NOTE:
SHEAVES IN BOOM HEAD AND HOOK BLOCK ARE NUMBERED FROM LEFT TO RIGHT AS VIEWED FROM THE OPERATOR'S STATION.
"D" INDICATES PINNED END OF ROPE.

These patterns represent some, though not all, of the options for reeving patterns for hookblocks. Always use a reeving pattern that allows the block to hang level.

HOIST LINE REEVING

When reeving the crane in preparation for any job, it should be kept in mind that hoisting and lowering speeds decrease as the number of parts of line increases. For the most efficient use of the crane, it is therefore desirable to use the minimum required number of parts for lifting the load as determined by referring to the load rating chart.

This crane incorporates a "Quick Reeving" boom head and block which do not require removal of the wedge and socket from the rope in order to change the reeving. Removal of two pins in the boom head and three in the hook block will allow the wedge and socket to pass through.

CAUTION

Never use less than the number of parts called for by the load rating chart.

If it is not practical to alter the reeving during the course of the work, the required number of rope parts must be determined on the basis of the heaviest load to be lifted during operations.

When the required number of rope parts has been determined, reeve the rope as shown on page 3-12. Attach a wedge type rope socket to the wire rope dead end and secure it to either the boom peak or hook block as required. Dead end the rope on the hook block for an odd number of line parts, and on the boom peak for an even number of parts.

As shipped from the factory, the crane has sufficient wire rope provided to allow the hook to each ground level with any boom length and elevation when reeved with minimum parts of line required for the load being lifted. Refer to the Crane Capacity Chart for parts of line required.

WIRE ROPE SPECIFICATIONS

MAIN WINCH

STD. - 3/4" 6X19 OR 6X37 IPS IWRC
PREFORMED RIGHT REG. LAY WIRE ROPE
WEIGHT 1.04 LBS/FT
MINIMUM BREAKING STRENGTH - 25.6 TONS

OPT. - 3/4" ROTATION RESISTANT
34 X 7 COMPACTED STRAND, GRADE 2160
WEIGHT 1.24 LBS/FT
MINIMUM BREAKING STRENGTH - 34.5 TONS

AUXILIARY WINCH

STD. - 3/4" 6X19 OR 6X37 IPS IWRC
PREFORMED RIGHT REG. LAY WIRE ROPE
WEIGHT 1.04 LBS/FT
MINIMUM BREAKING STRENGTH - 25.6 TONS

OPT. - 3/4" ROTATION RESISTANT
34 X 7 COMPACTED STRAND, GRADE 2160
WEIGHT 1.24 LBS/FT
MINIMUM BREAKING STRENGTH - 34.5 TONS

WARNING

UNDER NO CONDITIONS CAN ANY OTHER SIZE, TYPE, OR LENGTH OF WIRE ROPE BE USED ON THIS EQUIPMENT SINCE IT CONSTITUTES A SAFETY HAZARD

TRANSPORTING THE CRANE

The boom must be stowed in the boom rack before transporting the crane.

The boom extend sections should be restrained to prevent gradual roll-out when transporting the crane on a semitrailer. The hydraulic system will not hold the sections against the hard breaking jolts while the crane is being transported.

Restrain the boom extend sections by snugging the hook block against the boom head, or secure the boom head back to the base section of the boom with chains or cable. An extended(ing) boom can cause substantial damage.

SIDE STOW JIB

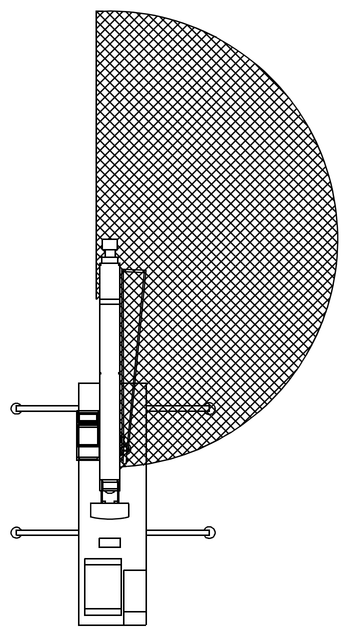
DESCRIPTION

Two optional jib extensions are available to provide additional boom reach. One is a 32ft (9.75 m) side stow swing-on one-piece lattice type jib that is offsettable at 0°, 15°, or 30°.

The second jib option is a 33-57 ft. (10.05 - 17.37 m) side stow swing-on lattice type jib. The jib is extendible to 57 ft. (17.37 m) by means of a 25ft. (7.62 m) manual pullout tip section.

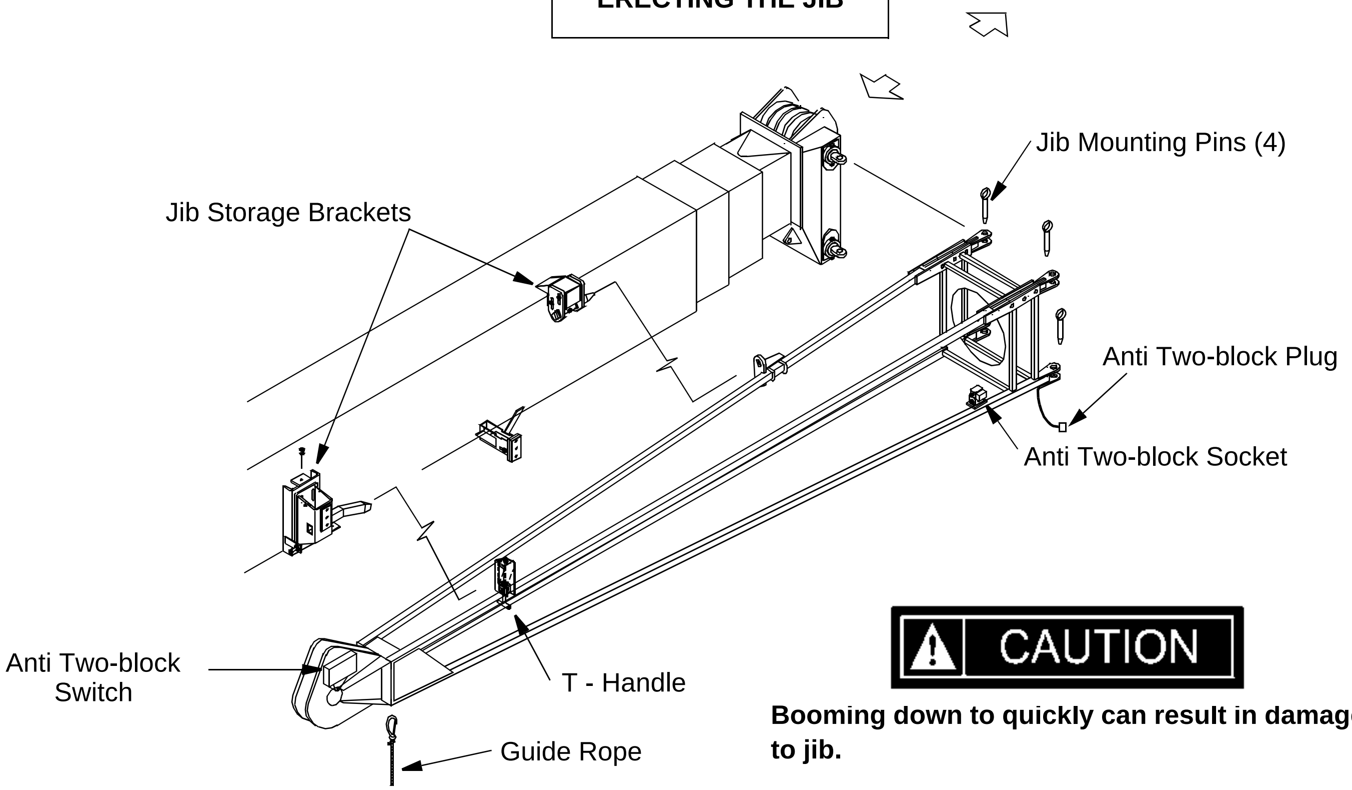
Each optional jib extension is pinned directly to the ends of the sheave pins. When not in use, the jib can be unpinned from the boom head and stored on mounting brackets on the right side of the boom base section.

The 32ft (9.75 m) jib weighs 1,280 pounds (581 kg). The 33-57 ft. (10.05-17.37 m) jib weighs 2,070 pounds (939 kg).



Before erecting or stowing the jib, ensure that no personnel or obstacles are in the swing path of the jib.

ERECTING THE JIB



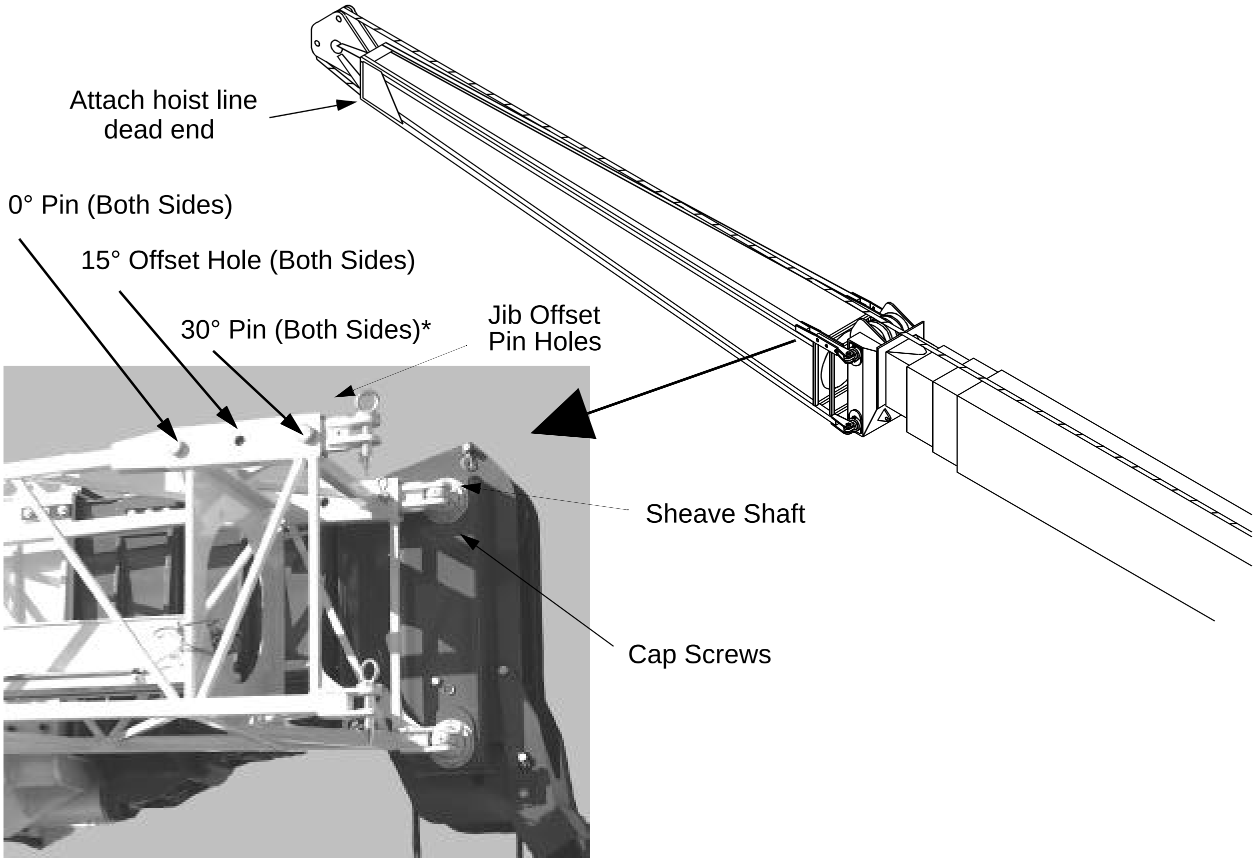
1. Extend and set the outriggers.
2. Rotate the upper structure to the "over rear" position.
3. Retract the boom completely.
4. Boom down to minimum boom angle to allow ease of installation of the jib pins. If necessary raise rear outriggers till boom head can be reached from ground level.
5. Install the upper and lower jib mounting pins in the right side of the boom head.
6. Attach a guide rope to the eye on the bottom tip of the jib.
7. Extend outriggers if retracted, to bring crane back to level. Raise the boom to horizontal.
8. Pull down and rotate the T - handle to unlock the jib from the storage bracket.
9. With the engine at idle, slowly extend the boom 2-3 feet (.6-1 m). As the jib clears the storage brackets, the jib will swing out approximately 45°.

CAUTION

Booming down to quickly can result in damage to jib.

10. With the engine at idle, slowly boom down to minimum boom angle while another operator uses the guide rope to control the speed of the jib rotation. The jib will swing around until the left side mounting holes line up.
11. If cable from main boom is to be used on jib, remove cable from boom head load sheaves and swing over top left jib cord before pinning jib to boom. Install the left upper and lower jib mounting pins.
12. Remove the guide rope.
13. Disconnect the anti two-block plug from the jib anti two-block socket and connect it to the socket on the boom head. Move the dummy plug from the boom head socket to the anti two-block socket on the jib.
14. Reeve the hoist line over the jib sheave.
15. Test the anti two-block system by lifting the anti two-block weight. The light and audible alarms should be actuated in the cab and the boom down, boom extend, and winch up controls should disconnect.

CHANGING THE OFFSET OF JIB



INCREASING OFFSET

1. Retract the boom and set the outriggers.

2. Boom down to minimum boom angle.

3. Loosen the two (2) cap screws on the left side of the upper and lower sheave shafts. This will require a 3/4 inch hex wrench.

4. Reeve the hoist line over the top center sheave on the boom head, around the jib sheave, and attach to the eye on the bottom of the jib tip.

5. Winch up to take the slack out of the hoist line and to take the weight of the jib off of the jib offset pins.

NOTE: *To prevent damaging the jib, do not winch up any more than is necessary to loosen the jib offset pins.*

6. Remove the jib offset pins from the 0° offset hole and place in the 15° hole or if you are using 30° offset then place pins in tool box.

WARNING

**** Never Remove Either 30° Pin***

7. With the engine at idle, slowly winch down to pay out hoist cable. This will lower the tip of the jib until the jib comes in contact with the jib offset pins.

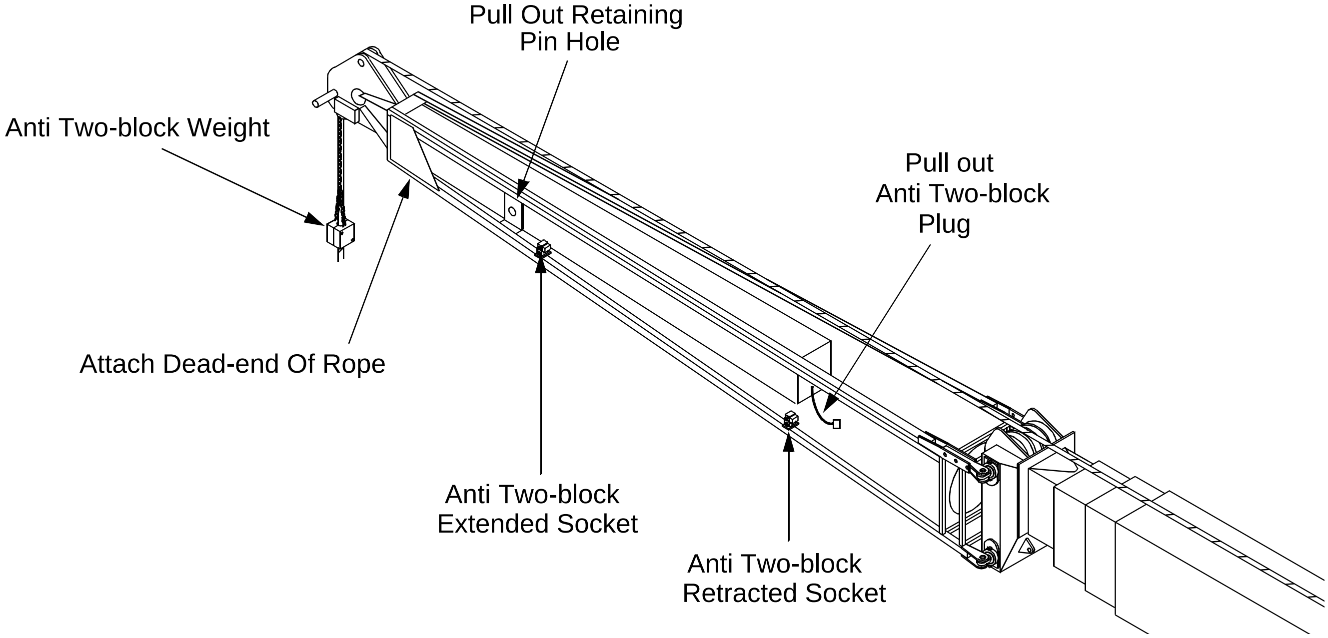
NOTE: *While lowering the tip of the jib, it may be necessary to raise the boom to prevent the tip of the jib from touching the ground.*

8. Remove the hoist line from the tip of the jib and reeve the hoist line as needed.

DECREASING OFFSET

1. Reverse above procedure to return jib to 0° offset position.

EXTENDING AND RETRACTING THE JIB PULLOUT SECTION



EXTENDING THE PULLOUT SECTION

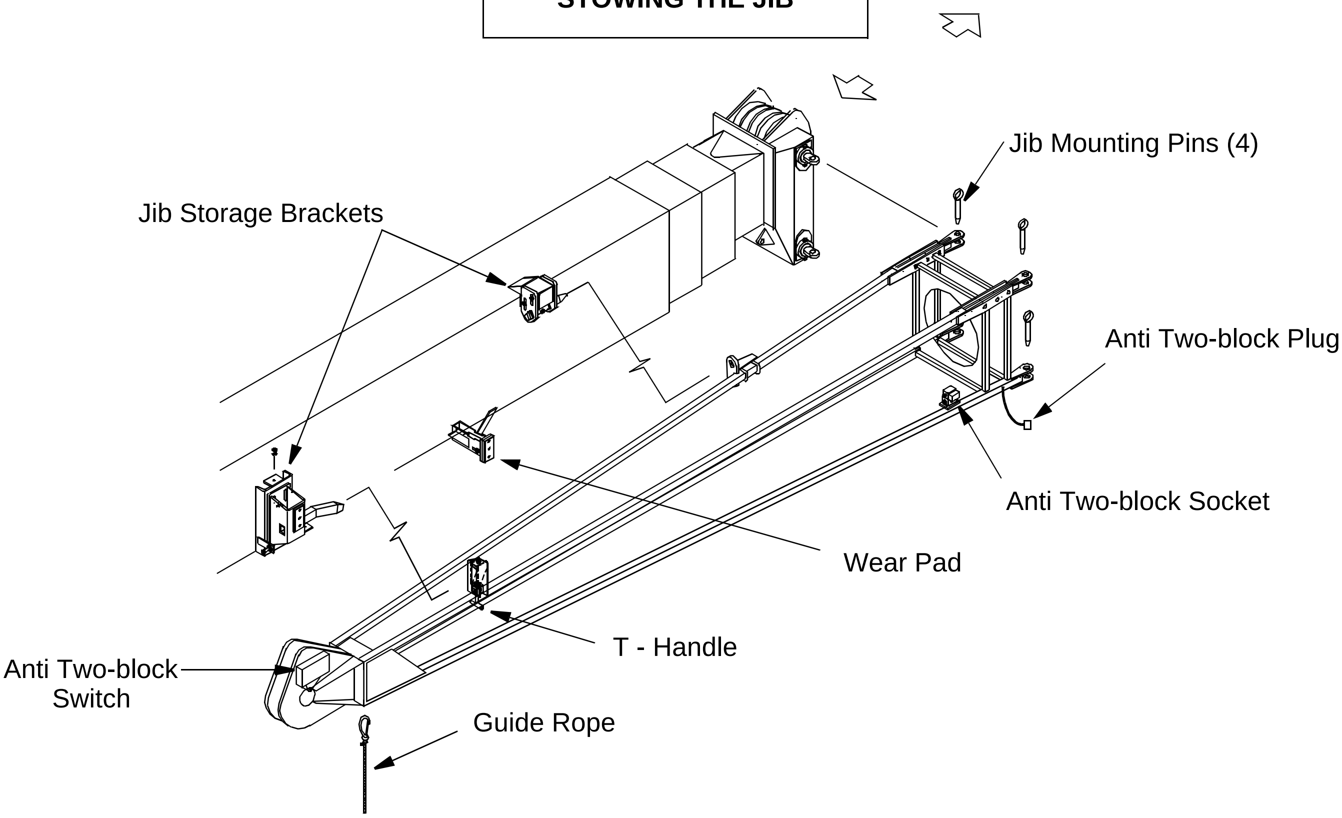
NOTE: The jib must be erected before extending the pullout section. Do not attempt to extend the pullout section while the jib is stowed.

1. Retract the boom completely and boom down to minimum boom angle.
2. Attach the dead end of the wire rope to the eye on the bottom of the jib tip. This is done to prevent the pullout from extending uncontrollably.
3. Unplug the pull out anti two-block plug from the anti two-block ***Retracted*** socket. Move the dummy plug from the extended socket to the retracted socket.
4. Remove pullout retaining pin from the retaining pin hole.
5. Pay out cable and extend the pullout until the retaining pin holes line up. Install retaining pin.
6. Plug the anti two-block plug into the anti two-block ***Extended*** socket.
7. Test the anti two-block system by lifting the anti two-block weight. The light and audible alarms should be actuated in the cab and the boom down, boom extend, and winch up controls should disconnect.

RETRACTING THE PULLOUT SECTION

1. Retract the boom completely and boom down to minimum boom angle.
2. Unplug the anti two-block plug from the anti two-block ***Extended*** socket. Move the dummy plug from the retracted socket to the extended socket.
3. Attach the dead end of the wire rope to the eye on the bottom of the jib tip.
4. Remove pullout retaining pin from the erected retaining pin hole.
5. Winch up slowly to retract the pullout until the retracted retaining pin holes line up and install retaining pin.
6. Plug the anti two-block plug into the anti two-block ***Retracted*** socket.
7. Test the anti two-block system by lifting the anti two-block weight. The light and audible alarms should be actuated in the cab and the boom down, boom extend, and winch up controls should disconnect.

STOWING THE JIB



STOWING THE JIB

WARNING

Before erecting or stowing the jib, ensure that no personnel or obstacles are in the swing path of the jib.

1. Extend and set the outriggers.

2. Rotate the upper structure to the “over rear” position.

3. Make sure the stinger is in the stowed position and the jib offset is at 0° offset.

4. Boom down to minimum boom angle.

5. Remove the hoist line from jib sheave and lay to left side.

6. Disconnect the anti two-block plug from the boom head and plug it in to the jib anti two-block socket. Move the dummy plug from the jib anti two-block socket to the boom head anti two-block socket.

7. Extend the boom to 2-3 feet (.6-1 m).

8. Attach the guide rope to the eye on the bottom tip of the jib.

9. Remove the left upper and lower jib mounting pins. With guide rope, pull left jib ears out of left boom head ears.

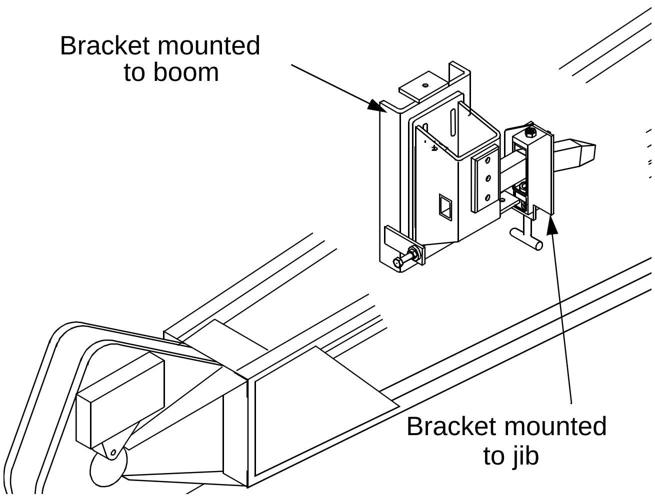
10. With the engine at idle, slowly boom up while a second operator holds the guide rope to control the rotating speed of the jib.

11. Boom up to approximately 30°. Allow the jib to swing around until the jib contacts the wear pad on the boom. As the jib gets close to the side of the boom, make sure the jib does not strike the side of the boom.

STOWING THE JIB

12. With the engine at idle, slowly retract the boom completely. The jib will engage the jib storage brackets as the boom is retracted.

13. Remove the guide rope from the tip of the jib.



14. As the boom is retracted, verify that the stowage bracket mounted to the jib is engaging properly with the stowage bracket mounted to the boom.

15. Rotate and release the T-handle to lock the jib to the storage brackets.

16. Remove the right upper and lower jib mounting pins.

17. Test the anti two-block system at the boom head by lifting the anti two-block weight. The light and audible alarms should be actuated in the cab and the boom down, boom extend, and winch up controls should disconnect.

UNUSUAL OPERATING CONDITIONS

Special problems in maintenance and operation are caused by unusual conditions such as extremes in heat, cold and humidity, high altitude, salt water, and dusty or sandy work sites. When operating under such conditions, special precautions must be taken to prevent damage, minimize wear, and avoid component deterioration.

EXTREME COLD In periods of extreme cold, the problems of freeze damage, adequate lubrication and battery failure may become particularly troublesome. With the onset of very cold weather, it is advisable to "winterize" the crane by servicing the cooling system and switching to the lubricants recommended for cold weather usage. Follow the recommendations in this manual when the crane must be operated in very cold conditions.

1. To prevent freeze damage to the cooling system and cracking of the engine block or head, drain and flush the cooling system. Clean the radiator exterior, making certain the air passages through the core and the cooling fins are free of foreign matter.

Refill the cooling system, adding an anti-freeze solution recommended by the engine manufacturer in an amount and strength appropriate to the anticipated temperatures. A corrosion inhibitor is recommended.

ATTENTION

Never use a chromate base corrosion inhibitor when the coolant contains ethylene glycol. Use only non-chromate base inhibitors. Chromate base inhibitors reacting with ethylene glycol can produce chromium hydroxide, commonly known as "green slime". This substance reduces the heat transfer rate and can cause serious engine overheating.

Inspect the thermostat, clamps, radiator hoses and radiator core for proper condition. Replace or repair any cooling system component found to be defective.

2. Condensation in the fuel tank contaminates the fuel supply with water, which can freeze in the fuel lines and block the fuel flow to the engine. To minimize this possibility, keep the tank as full as is practical during cold weather. This may entail refilling the tank more frequently than usual, but the inconvenience is small compared to clearing a blocked fuel line.

If water should be noticed in the fuel supply, drain the tank and refill it with uncontaminated fuel.

3. Lubricate the crane with the lubricants recommended for cold weather operation on the Lubrication Chart. If necessary, change the engine oil and other lubricants in order to conform to the recommendations.

4. The battery is more likely to sustain freeze damage if not kept fully charged because its electrolyte will freeze at a higher temperature than that in a fully charged battery. Be certain the battery is charging when the engine is running and use an external charger to restore full charge when the crane is not being operated.

The battery can discharge if snow or ice short circuits the terminals. Keep the battery posts and cable connectors clean and dry. Remove any corrosion with a solution of soda and water.

During extremely cold weather, it is advisable to remove and store the battery in a heated area when the crane is to remain idle overnight or for any extended period.

AIR BRAKES At least once a day, drain the water accumulation from the air tanks, and check the alcohol evaporator fluid level. Fill with methyl alcohol only.

5. Special attention must be given to the hydraulic oil during very cold weather.

ATTENTION

NEVER ENGAGE THE HYDRAULIC PUMP AND ACTUATE THE HYDRUALIC SYSTEM BEFORE THE HYDRAULIC OIL IS WARM. Cold, sluggish oil can cause pump cavitation. If the crane is not equipped with a reservoir immersion heater and running the oil over relief will not warm it sufficiently to prevent pump cavitation with the engine running very slowly, cease attempts to engage the pump until an external heat source can be obtained.

Once the reservoir is warm to the touch, actuate the hydraulic system by engaging the hydraulic pump. Continue warming the oil and slowly cycle all crane functions, actuating all cylinders in turn, swinging the upper and operating the winches in both directions.

The hydraulic oil may be run over relief to aid in the warm-up process. To do this, actuate a func- tion, allow the cylinders involved to reach the limits of their travel and hold the control in the engaged position for a few seconds.

When running hydraulic oil over relief to warm it, be sure to restrict the flow to as slow a speed as possible by moderating pressure on the controls being engaged and running the engine at low speed.

6. At the end of the work period, or whenever the crane is to be left idle for extended periods, prevent it from being frozen to the ground by parking it on a wood, concrete, asphalt or mat surface.

EXTREME HEAT Like extreme cold, requires that precautions be taken with respect to the cooling system, the battery and lubrication. Protect the crane by performing the following recommended procedures:

1. High temperatures necessitate the use of lubricants which are both more viscous and which resist deterioration at higher operating temperatures. Refer to the Lubrication Chart and lubricate the crane using the lubricants recommended for the expected temperatures.

Crankcase oil is particularly important because it helps dissipate heat. Check the oil level frequently and add oil as necessary to maintain required level. Too little oil will hinder heat dissipation.

2. To ensure proper coolant circulation, drain and flush the cooling system, clean any foreign matter from the radiator cooling fins and through core air passages, replace defective hoses, tighten hose clamps, tension the water pump drive belt properly, eliminate any leaks detected and fill the system with a 50% solution of ethylene glycol. A corrosion inhibitor is recommended.

Engine overheating due to loss of coolant will most often be corrected by SLOWLY adding coolant while the engine is running at FAST IDLE. Should this fail to correct the problem, drain and flush the system and refill with fresh coolant (50% solution of ethylene glycol) and a corrosion inhibitor.

CAUTION

Allow the engine to cool before draining and flushing the cooling system.

Water containing more than small concentrations of salt or minerals should not be used in the cooling system. Salt facilitates corrosion and minerals deposited on the coolant passage walls. Both processes inhibit proper cooling.

3. Air circulation around the engine and battery must not be restricted. Keep air intake and exhaust openings clear of leaves, paper or other foreign matter which may restrict air flow.

4. Keep the engine clean of dirt, grease and other substances which inhibit heat dissipation.

5. Use sound judgment in operating the engine. Avoid the two extremes of racing and lugging.

Advance the throttle only enough to handle the load, yet be certain that the engine speed is high enough to maintain adequate fan speed for cooling.

Run the engine only when engaged in work opertions or when traveling the crane. Avoid prolonged periods at idle and shut the engine down if operations are interrupted.

SANDY OR DUSTY WORK SITES The presence of large amounts of sand or dust at the work site can contribute to accelerated component wear. Either substance will act as an abrasive when deposited on moving parts of the crane. The problem is combated by more frequent lubrication and by the servicing of breathers and filters at shorter intervals. Follow the recommendations below when operating in sand or dust on a regular basis.

1. Keep sand and dust out of the hydraulic system by keeping the reservoir filler cap tight and servicing the hydraulic system filters frequently.

2. The fuel system should be kept free of sand and dust by keeping the tank filler cap tight and servicing the fuel filters frequently.

3. The engine breathers and air cleaner should also be serviced frequently to prevent sand and dust from entering the engine. The engine oil and oil filter should be changed at shorter than normal intervals to ensure a clean oil supply to the engine's moving parts.

4. When lubricating the crane, thoroughly clean each grease fitting before attaching the grease gun. Pump generous amounts of grease into all lubrication points, using the fresh grease to pump out the old.

5. Adequate ground bearing support must be provided for the outrigger floats when operating in sand. Be alert for signs of carrier movement during operations.

The increased frequency of lubrication and service discussed above should be determined by observations made at the work site. Inspection will determine how long it takes for lubricants, breathers and filters to accumulate unacceptable amounts of sand or dust. The frequency of lubrication and service should be adjusted accordingly.

HIGH HUMIDITY OR SALTWATER In some locations, such as coastal areas, the crane may be exposed to the deteriorating effects of salt, moisture, or both. To protect exposed metallic surfaces, wiring, hoist rope, paint and other items, keep them dry and well lubricated where salt or high humidity are encountered. Follow the recommendations below when operating in these conditions:

1. Make frequent inspections for rust and corrosion and remove them as soon as they are detected. Dry and paint exposed surfaces after rust and corrosion have been removed.

2. Where paint may not be applied, such as on polished or machined surfaces, coat the area with grease or lubricant to repel water.

3. Keep bearings and their surrounding surfaces well lubricated to prevent the entry of water.

4. Hoist rope must be kept well lubricated to prevent moisture and salt from penetrating the cable strands.

HIGH ALTITUDES Variations in altitude alter the fuel-air mixture burned in the engine and affect the engine's performance. At high altitudes, atmospheric pressures are lower and less oxygen is available for combustion of the fuel. Above 10,000' the engine fuel injectors may have to be changed to ensure proper performance. Consult engine manufacturer should this problem arise.

Keeping the air cleaner clean and free of obstructions will help alleviate high altitude problems.

At high altitudes, closely monitor the engine temperature for overheating.

STORMS

In case of storms, take the following precautions:

- If possible, support the load and completely retract the boom.

- If caught by a sudden storm, switch off the engine and leave the machine.

- If the machine is struck by lightning, check general machine operation before restarting it.

You must always know the weather forcasts of your area before starting work.

LOAD RATING CHART INTERPRETATION

In the following pages are examples of a load chart, these example charts may differ from the chart supplied with your crane. Always use the load rating chart supplied with the crane to interpret the conditions and limitations that exist when making a lift with the crane. The determining factors are lifted load, radius, boom angle, working position, hoist line reeving, tire pressure, travel data, use of a jib, and any other special conditions that exist, such as wind velocity, soil conditions, etc.

DEFINITIONS OF LOAD CHART TERMS

Lifted Load:
The lifted load is the total weight of all the items suspended on the wire rope.

Example

Hook block	750 lbs.
Slings	215 lbs.
Object Lifted	19,000 lbs.
Lifted Load	19,965 lbs.

Radius:
The radius is the horizontal distance from the center of the swing bearing to the center of the lifted load.

CAUTION

Deflection of the crane boom will tend to increase the radius as the load is lifted. To minimize this, use the combinations of boom angle and length shown in the load rating chart. Do not allow the radius to exceed that given for the rated load.

Boom Angle :
The boom angle is the angle of the boom measured from horizontal. Use the angles shown to approximate the loaded radius, but do not rely solely on a boom angle indicator to determine radius. Always measure the actual radius when determining main boom capacities.

Front and 360°:
The "crane working position" diagram is a view looking straight down on the crane with the upperstructure and the boom removed. The "front" of the crane is always the end opposite the engine.

"Front" when the crane is on outriggers is the area inside the are bounded by lines from the centerline of rotation through the front outrigger vertical jack cylinders.

"St. over Front" when operating on tires means the boom and load must be positioned straight to the front of crane and not swung to right or left.

360° means the load can be swung to any position around the crane.

Deducts:
The "on outriggers" rated capacities are for lifting over the main boom point. Jibs, if so equipped, are in the stowed position. Any specialty items attached to the boom head should be removed. In certain instances, it is advantageous, from a job set-up point of view, to lift over the main boom point with the jib erected. In these instances, it is necessary to make deductions from the rated loads shown in the load rating chart to determine the correct rated load. Hook blocks or any specialty items should be removed from the jib point when lifting over the main boom point.

REDUCTION IN MAIN BOOM CAPACITY

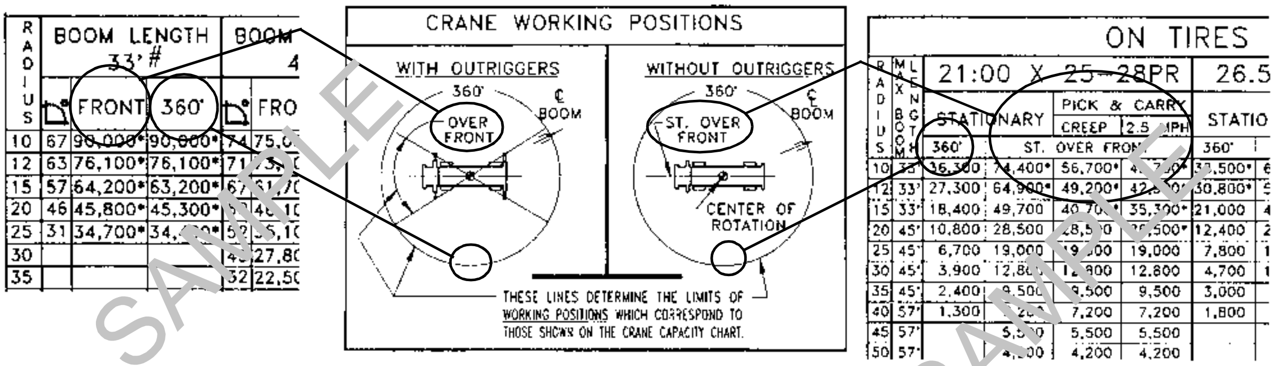
ALL JIBS IN STOWED POSITION	0 Lbs.
33'-58' OFFSET JIB JIB ERECTED WITHOUT STINGER	3,000 Lbs.
33'-58' OFFSET JIB JIB ERECTED STINGER RETRACTED	4,800 Lbs.
33'-58' OFFSET JIB JIB ERECTED STINGER EXTENDED	6,300 Lbs.
AUX. BOOM HEAD SHEAVE	110 Lbs.

HOOK BLOCK WEIGHTS

HOOK & BALL	239 Lbs.
HOOK BLOCK (3 SHEAVE)	650 Lbs.
HOOK BLOCK (4 SHEAVE)	700 Lbs.
HOOK BLOCK (5 SHEAVE)	750 Lbs.

SAMPLE

Also, there are deductions for jib operation due to hook blocks hanging on the main boom point. In this circumstance, reduce the jib capacity by the weight of the hook block and/or other specialty items hanging from the main boom point.



Cut-Offs:

Rated chart values of less than 1,000 lbs. for on outriggers, side-stow and stow-away jibs are not shown. On rubber values less than 600 lbs. are not shown. This is done because the effects of wind, pendulum action, jerking, etc., can cause a tip over. Therefore:

CAUTION

Extending the boom or boom and jib combination into unrated areas of the chart can cause tip over. See Note 19 on Load Chart.

LOAD CHART NOTE

19. CRANE LOAD RATINGS WITH AN ASTERISK (*) BESIDE THEM ARE BASED ON THE CRANE'S STUCTURAL STRENGTH. ALL OTHER RATINGS ARE BASED ON STABILITY AND DO NOT EXCEED THE SPEWCIFIED PERCENTAGE OF TIPPING LOAD AS DETERMINED BY SAE CRANE STABILITY TEST CODE J-765A.

Note on the accompanying examples that a significant portion of the range of the machine is unrated. The side stow jib at 30° offset, with full boom is longer than 123 ft. but is cutoff at 123 ft. radius. The "On Tire" chart shows the crane cannot be operated beyond a 60 ft. radius on tires.

CAUTION

Do not operate at a longer radius than those listed on the applicable load rating charts as tipping can occur without a load on the hook.

SIDE STOW JIB ON OUTRIGGERS

	33' OFFSET JIB						[illegible]8' OFFSET JIB						
	MAX BOOM & 0' OFFSET 138.6'		MAX BOOM & 15' OFFSET 137.8'		MAX BOOM & 30' OFFSET 134.9'		MAX BOOM [illegible] 0' OFFSET 163.6'		MA[illegible] BOOM & 1[illegible] OFFSET 161.9'		MAX BOOM & 30' OFFSET 156.5'		
	RAD. (REF)	360°	RAD. (REF)	360°	RAD. (REF)	360[illegible]	[illegible]	[illegible]	RAD. (REF)	360°	RAD. (REF)	360°	
75	38	9,000*	46	7,200*	52	6,0[illegible]*	50	5,000*	64	4,000*	75	3,300*	75
73	43	7,700*	50	6,600*	57	[illegible]500	55	4,700*	69	3,800*	79	3,200*	73
70	50	6,300*	56	5,700*	63	[illegible]	[illegible]	4,300*	76	3,500*	86	2,900*	70
67	57	5,400*	63	4,900*	[illegible]	4,[illegible]	71	3,900*	83	3,200*	92	2,700*	67
64	63	4,500*	69	4,200*	[illegible]	[illegible]	78	3,300*	90	2,800*	98	2,500*	64
61	70	3,900*	76	[illegible]	81	3,300*	86	2,800*	97	2,400*	104	2,200*	61
58	76	3,300*	81	[illegible]	[illegible]	[illegible],800*	93	2,400*	103	2,100*	110	1,900*	58
54	83	2,700*	88	2,5[illegible]	93	2,300*	102	1,900*	[illegible]	1,600*	[illegible]	1,500*	54
50	90	2,100*	[illegible]	2,00[illegible]	99	1,900*	110	1,500*	118	1,200*	123	1,200*	50
46	97	1,700*	101	[illegible]	105	1,500*	117	1,100*					46
42	103	1,200*	[illegible]	1,2[illegible]0*	110	1,100*							42

ON TIRES

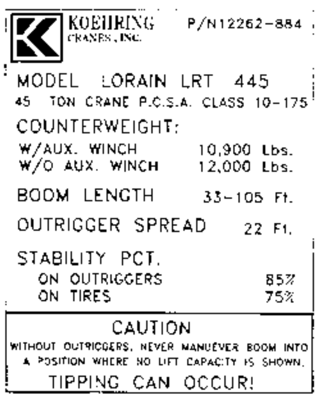
RADIUS	MAX BOOM LENGTH	21:00 X 25-28PR				26.5 X 25-26PR				RADIUS
		STATIONARY		PICK & CARRY		STATIONARY		PICK & CARRY		
				CREEP	2.5 MPH			CREEP	2.5 MPH	
		360°	ST. OVER FRONT			360°	ST. OVER FRONT			
10	33'	36,300	74,400*	56,700*	49[illegible]*	[illegible]500	65,600*	49,700*	41,600*	10
12	33'	27,300	64,900*	49,200*	[illegible],900	30,[illegible]*	57,000*	42,900*	35,800*	12
15	33'	18,400	49,700	40,700	35,[illegible]0*	21,000	47,300*	35,300*	29,200*	15
20	45'	10,800	28,500	28,500	[illegible]	12,400	28,500	26,500*	21,600*	20
25	45'	6,700	19,000	19[illegible]	[illegible]	7,800	19,000	19,000	16,400*	25
30	45'	3,900	12,800	12,8[illegible]	[illegible],800	4,700	12,800	12,800	12,400*	30
35	45'	2,400	9,500	[illegible]	9,500	3,000	9,500	9,500	9,500	35
40	57'	1,300	7,200	[illegible],200	7,200	1,800	7,200	7,200	7,200	40
45	57'		5,500	[illegible],500	5,500		5,500	5,500	5,500	45
50	57'		[illegible],200	4,200	4,200		4,200	4,200	4,200	50
55	69'		3,[illegible]	3,100	3,100		3,100	3,100	3,100	55
60	69'		2,300	2,300	2,300		2,300	2,300	2,300	60

On Outriggers Load Ratings:
To determine the boom extension capacities with the crane on outriggers, use the following procedure:

1. Determine weight of load to be lifted.
2. Determine weight of slings and rigging hardware.
3. Determine weight of hook block.
4. Determine other capacity deductions.
5. Calculate weight of lifted load.
6. Determine load radius, boom angle, and boom length.
7. Compare load weight with chart rated capacity for the boom length, radius, and boom angle.
8. The lifted load must not exceed the chart rated capacity for the boom length and radius.

In this example, the lifted load of 25,300 lbs. is less than the rated load of 27,800 lbs. and can be handled as long as the machine is on outriggers per Notes 6 & 7, the load stays at 30 feet of radius or less, the conditions of Note 18 are met and the machine is equipped per Lift Chart specifications.

CHART SPECIFICATIONS


KOEHRING CRANES, INC. P/N12262-884

MODEL LORAIN LRT 445
45 TON CRANE P.C.S.A. CLASS 10-175

COUNTERWEIGHT:
W/AUX. WINCH 10,900 Lbs.
W/O AUX. WINCH 12,000 Lbs.

BOOM LENGTH 33-105 Ft.

OUTRIGGER SPREAD 22 Ft.

STABILITY PCT.
ON OUTRIGGERS 85%
ON TIRES 75%

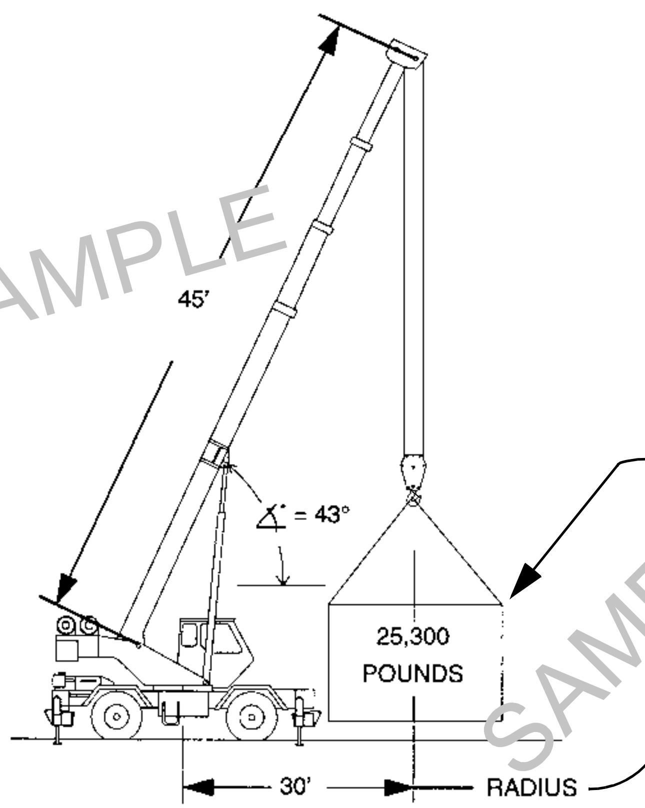
CAUTION
WITHOUT OUTRIGGERS, NEVER MANUEVER BOOM INTO A POSITION WHERE NO LIFT CAPACITY IS SHOWN.
TIPPING CAN OCCUR!

Example

Hook Block	750 lbs.
Slings	300 lbs
Object Lifted	24250 lbs.
Load Lifted	= 25300 lbs.

LOAD CHART NOTES

6. CRANE LOAD RATINGS ARE BASED ON THE CRANE BEING LEVELED AND STANDING ON FIRM, UNIFORM SUPPORTING SURFACE.
7. CRANE LOAD RATINGS ON OUTRIGGERS ARE BASED ON ALL OUTRIGGER BEAMS FULLY EXTENDED AND THE TIRES RAISED FREE OF THE SUPPORTING SURFACE.
18. PRACTICAL WORKING LOADS DEPEND ON THE SUPPORTING SURFACE, WIND VELOCITY, PENDULUM ACTION, JERKING OR SUDDEN STOPPING OF LOADS, HAZARDOUS SURROUNDINGS, EXPERIENCE OF PERSONNEL AND PROPER OPERATION, TIRE INFLATION, TIRE CONDITION, TRAVELING WITH LOADS, MULTIPLE CRANE LIFTS, PROXIMITY OF ELECTRICAL WIRES, ETC. APPROPRIATE REDUCTION OF LOAD RATINGS MUST BE MADE FOR THESE AND ANY OTHER CONDITIONS WHICH MAY AFFECT PRACTICAL WORKING LOADS.



RADIUS	BOOM LENGTH 33' #			BOOM LENGTH 45'		
	∡	FRONT	360°	∡	FRONT	360°
10	67	90,000*	90,000*	74	75,000*	75,000*
12	63	76,100*	76,100*	71	73,000*	72,900*
15	57	64,200*	63,200*	67	61,700*	61,700*
20	46	45,800*	45,300*	60	46,100*	45,600*
25	31	34,700*	34,400*	52	35,100*	34,800*
30				43	27,800*	27,600*
35				32	22,500*	22,400*
40				15	17,600*	17,500*
45						
50						
55						
60						
65						
70						
75						
80						
85						
90						
95						
100						

JIBS

To determine the jib capacities of the crane with all boom lengths, use the following procedure:

1. Determine weight of load to be lifted.
2. Determine weight of slings and rigging hardware.
3. Determine weight of hook block.
4. Determine capacity deductions.
5. Calculate weight of lifted load.
6. Determine jib type and length, jib offset, main boom angle.
7. Select correct jib load chart (stowaway or side-stow).
8. Compare load weight with chart rated capacity for the jib length, boom angle, and jib offset (if applicable).

SIDE-STOW JIB

⚠ CAUTION

Jibs are rated by boom angle only and not by radius. This means that as long as the boom is at 61° boom angle and the jib at 30° offset, before loading, no matter if the boom is fully extended or retracted, it can only lift a maximum of 3,300 lbs. on a 33 foot side-stow jib. The radius shown in the jib chart is the expected radius with a fully extended boom and jib after loading and deflection.

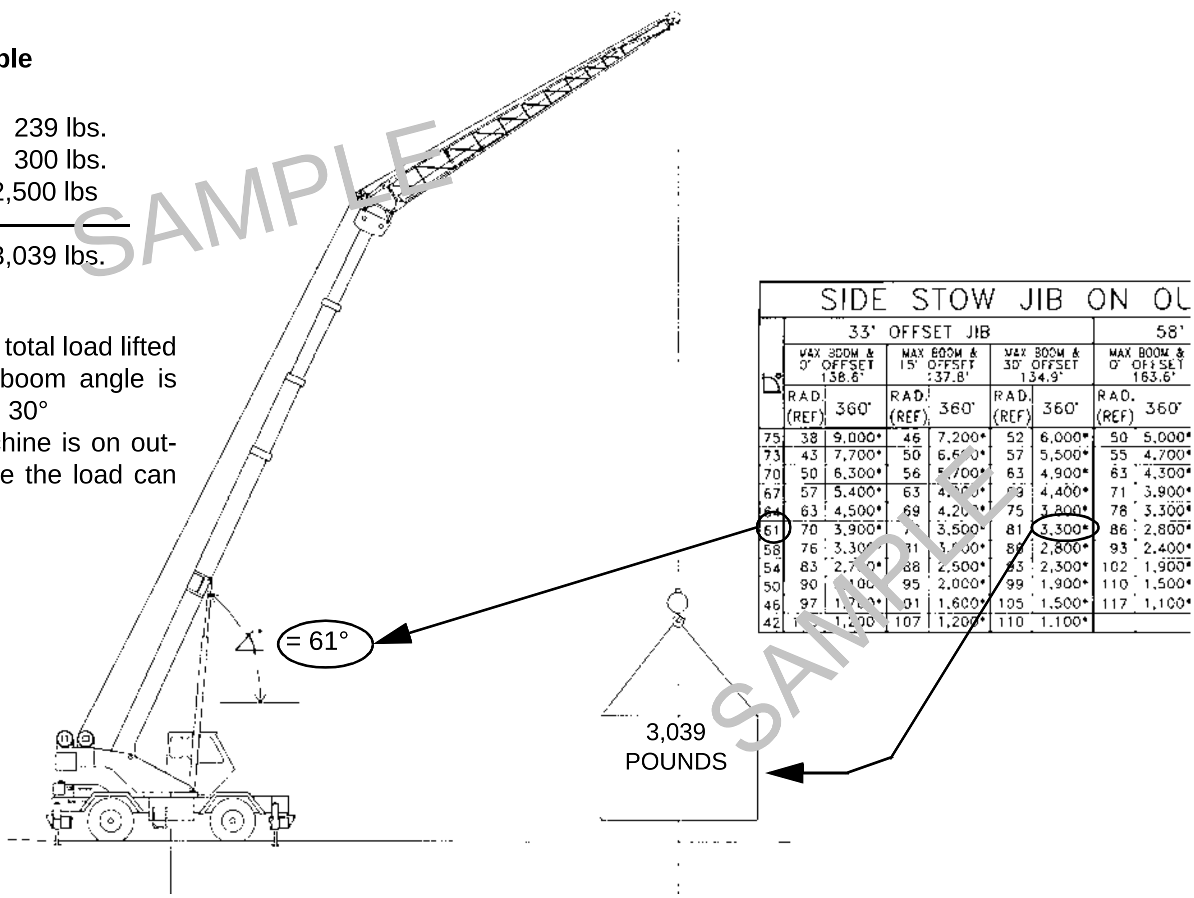
⚠ CAUTION

Never use a jib for clamshell or magnet operation. The heavy side load due to swinging and bouncing that can occur could damage jib or boom point. This is also true of pick and carry operations.

Example

Hook & Ball	239 lbs.
Slings	300 lbs.
Object Lifted	2,500 lbs
Load Lifted =	3,039 lbs.

In this example the total load lifted is 3,039 lbs. The boom angle is 61°, the jib is at the 30° offset and the machine is on outriggers. In this case the load can be safly lifted.



JIBS

To determine the jib capacities of the crane with all boom lengths, use the following procedure:

1. Determine weight of load to be lifted.
2. Determine weight of slings and rigging hardware.
3. Determine weight of hook block.
4. Determine capacity deductions.
5. Calculate weight of lifted load.
6. Determine jib type and length, jib offset, main boom angle.
7. Select correct jib load chart (stowaway or side-stow).
8. Compare load weight with chart rated capacity for the jib length, boom angle, and jib offset (if applicable).

In the following example the crane is set up as follows:

1. On outriggers.
2. Side stow jib erected at 30° offset.
3. Auxiliary boom head sheave erected but not used.
4. Hook block off the main head but not used.
5. Boom angle of 61°.

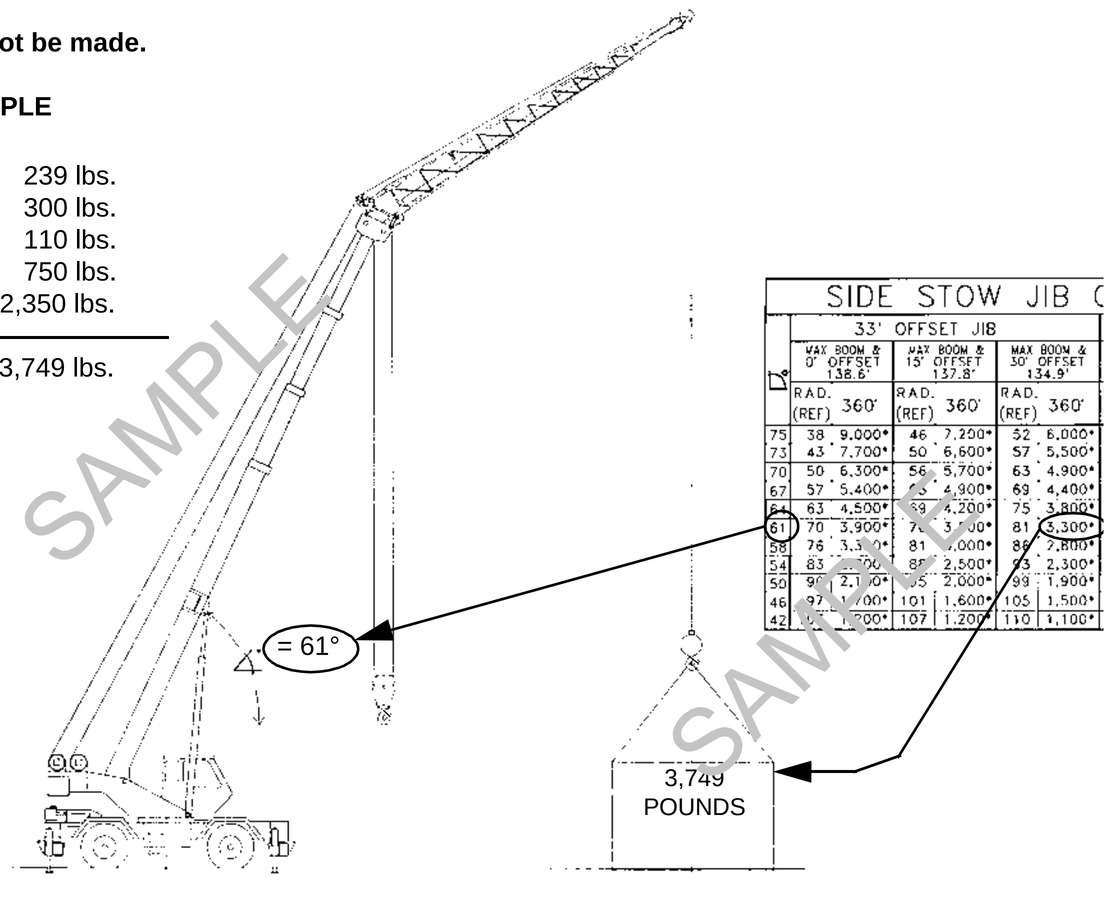
At first glance it appears that the 2,350 lb. object to be lifted is well within the capacity of the jib however after making the deductions for the erected and unused equipment and figuring the additional weight for slings and the hook & ball this lift CANNOT be made.

Note: Deductions for erected but unused equipment can either be deducted from the capacity OR added to the weight to be lifted. In this case we will add the weight to the load.

This lift cannot be made.

EXAMPLE

Hook & Ball	239 lbs.
Slings	300 lbs.
Auxiliary Head	110 lbs.
Hook Block	750 lbs.
Object	2,350 lbs.
Actual Load	= 3,749 lbs.



ON TIRES

⚠ CAUTION

On tires operation, particularly pick and carry, must be done in a slow, smooth manner over level terrain that will support the crane, with the loads close to the ground and the boom as low as possible to avoid the load swinging unintentionally, causing injury or tip over. Do not pick and carry with the jib since the load is further extended from the machine and the jib can be easily damaged.

The maximum boom length shown on the On Tire chart is the maximum boom length that can be used at the radius shown. This is done to limit the boom height when working on tires. Do not exceed the maximum boom length for the given radius.

.

ON TIRES

RADIUS	MAX BOOM LENGTH	21:00 X 25–28PR STATIONARY 360°	21:00 X 25–28PR STATIONARY ST. OVER FRONT	21:00 X 25–28PR PICK & CARRY CREEP	21:00 X 25–28PR PICK & CARRY 2.5 MPH	26.5 X 25–26PR STATIONARY 360°	26.5 X 25–26PR STATIONARY ST. OVER FRONT	26.5 X 25–26PR PICK & CARRY CREEP	26.5 X 25–26PR PICK & CARRY 2.5 MPH	RADIUS
10	33'	36,300	74,400*	56,700*	49,700*	38,500*	65,600*	49,700*	41,600*	10
12	33'	27,300	64,900*	49,200*	42,900*	[illegible],800*	57,000*	42,900*	35,800*	12
15	33'	18,400	49,700	40,700*	35,300[illegible]	21,[illegible]	47,300*	35,300*	29,200*	15
20	45'	10,800	28,500	28,500	26,500*	[illegible]400	28,500	26,500*	21,600*	20
25	45'	6,700	19,000	19,000	[illegible]	[illegible]	19,000	19,000	16,400*	25
30	45'	3,900	12,800	12,800	[illegible]	[illegible]700	12,800	12,800	12,400*	30
35	45'	2,400	9,500	[illegible]	[illegible]	3,000	9,500	9,500	9,500	35
40	57'	1,300	7,200	[illegible]	7,200	1,800	7,200	7,200	7,200	40
45	57'		5,500	[illegible]	5,500		5,500	5,500	5,500	45
50	57'		[illegible]	[illegible]	4,200		4,200	4,200	4,200	50
55	69'		[illegible]	[illegible]	3,100		3,100	3,100	3,100	55
60	69'		[illegible]	2,300	2,300		2,300	2,300	2,300	60

"Stationary" means that the crane cannot be moved when loaded to the levels shown in the on tire load chart.

⚠ CAUTION

Ensure that the tires are inflated as shown in the recommended tire pressure chart. Refer to procedure for tire inflation in Section 4, Page 4-12.

RECOMMENDED TIRE PRESSURE

TIRE SIZE	STATIONARY	CREEP	2 1/2 MPH	TRAVEL
21:00 X 25–28 PR	85 PSI	85 PSI	85 PSI	65 PSI
26:50 X 25–26 PR	[illegible]5 PSI	65 PSI	65 PSI	50 PSI

"Creep" means the crane can be moved at a maximum speed of one (1) MPH for a distance of 200 feet and then a 30 minute waiting period is necessary to cool the tires. Overheating will greatly reduce the life of the tires.

⚠ CAUTION

Never move the crane carrying a load with the boom in any position except straight over the front.

2.5 MPH means the crane can be driven at this speed, or slower, with the tires at the proper inflation pressure with the boom straight over the front.

STABILITY/ STRUCTURAL STRENGTH

ON OUTRIGGERS

RADIUS	BOOM LENGTH 33' #			BOOM LENGTH 45'			BOOM LENGTH 57'			BOOM LENGTH 69'			BOOM LENGTH 81'			BOOM LENGTH 93'			BOOM LENGTH 105'			RADIUS
	∠°	FRONT	360°	∠°	FRONT	360°	∠°	FRONT	360°	∠°	FRONT	360°	∠°	FRONT	360°	∠°	FRONT	360°	∠°	FRONT	360°	
10	67	90,000*	90,000*	74	75,000*	75,000*																10
12	63	76,100*	76,100*	71	73,000*	72,900*	74	59,600*	59,600*													12
15	57	64,200*	63,200*	67	61,700*	61,700*	72	55,000*	55,000*	75	43,900*	43,900*										15
20	46	45,800*	45,300*	60	46,100*	45,600*	66	46,300*	45,700*	71	36,100	[illegible]	75	33,400*	33,400*							20
25	31	34,700*	34,400*	52	35,100*	34,800*	60	35,300*	35,000*	67	30,300*	[illegible]	71	28,300*	28,300*	74	22,100*	22,100*				25
30				43	27,800*	27,600*	54	28,000*	27,800*	62	[illegible]	26,000*	67	24,200*	24,200*	71	18,900*	18,900*	74	15,000*	15,000*	30
35				32	22,500*	22,400*	47	22,800*	22,600*	[illegible]	[illegible]	22,700*	63	21,000*	21,000*	68	16,200*	16,200*	71	13,300*	13,300*	35
40				15	17,600*	17,500*	40	18,900*	18,700	[illegible]	[illegible]	18,700	59	18,600*	18,600*	64	14,200*	14,200*	68	11,900*	11,900*	40
45							32	15,800*	[illegible]	46	15,800*	15,000	55	15,800*	15,000	61	12,300*	12,300*	65	10,700*	10,700*	45
50							20	12,700	11,700	[illegible]	12,800	12,100	50	12,900	12,200	57	10,800*	10,800*	62	9,500*	9,500*	50
55										33	10,500	9,900	45	10,600	10,100	53	9,600*	9,600*	59	8,500*	8,500*	55
60										24	8,600	8,100	39	8,800	8,300	49	8,600*	8,400	55	7,500*	7,500*	60
65													33	7,300	6,900	44	7,400	7,000	52	6,600*	6,600*	65
70													26	6,100	5,700	39	6,100	5,700	48	5,900*	5,800	70
75													15	5,000	4,600	34	5,100	4,700	43	5,200*	4,800	75
80																28	4,200	3,900	39	4,200	3,900	80
85																19	3,400	3,100	33	3,500	3,200	85
90																			29	2,800	2,500	90
95																			20	2,200	1,900	95
100																			11	1,600	1,400	100

Crane load ratings with an asterisk (*) beside them are based on the machine's structural strength. All other ratings are based on stability. Therefore, when lifting in an area where the rated load is governed by strength, an overload can produce an abrupt failure. This may be in the boom, outrigger beam, or elsewhere. For example, this is particularly true when the operator does not know the weight of the lifted load or fails to account for the forces necessary to unstick a load from the mud or the extra ice, snow, mud, etc. on the load.

In the stability zone, some operators attempt to determine if the crane can lift the load by allowing the crane to tip. This can result in a tip over, particularly if the boom point moves out to a greater radius than the load centerline, which it tends to do due to boom deflection and machine tipping. In this condition, when the load comes free of the ground, it swings out rapidly, endangering workmen and can pull the crane into a tip over condition. Also, if the load is heavy enough and will not move and the boom point moves out far enough, the rating can change back to structural with the associated abrupt failure discussed above

.

⚠ CAUTION

Therefore: *CAUTION - Do not attempt to tip the machine to determine allowable load.*

MAXIMUM PERMISSIBLE HOIST LINE LOAD

By lifting with the boom or telescope cylinders, the crane can easily exceed the rated capacity of the wire rope and even the breaking strength of the wire rope. It is mandatory that wire rope utilized on the crane have adequate breaking strength as rated by the rope manufacturer, be in good condition, and proper number of parts of line be used. See Page 4-32 for maintenance and inspection and consult PCSA Std. No.4 and ANSI Standard B30.5 and the wire rope users manual.

INDEX

SECTION 4

RT700 SERIES

LUBRICATION

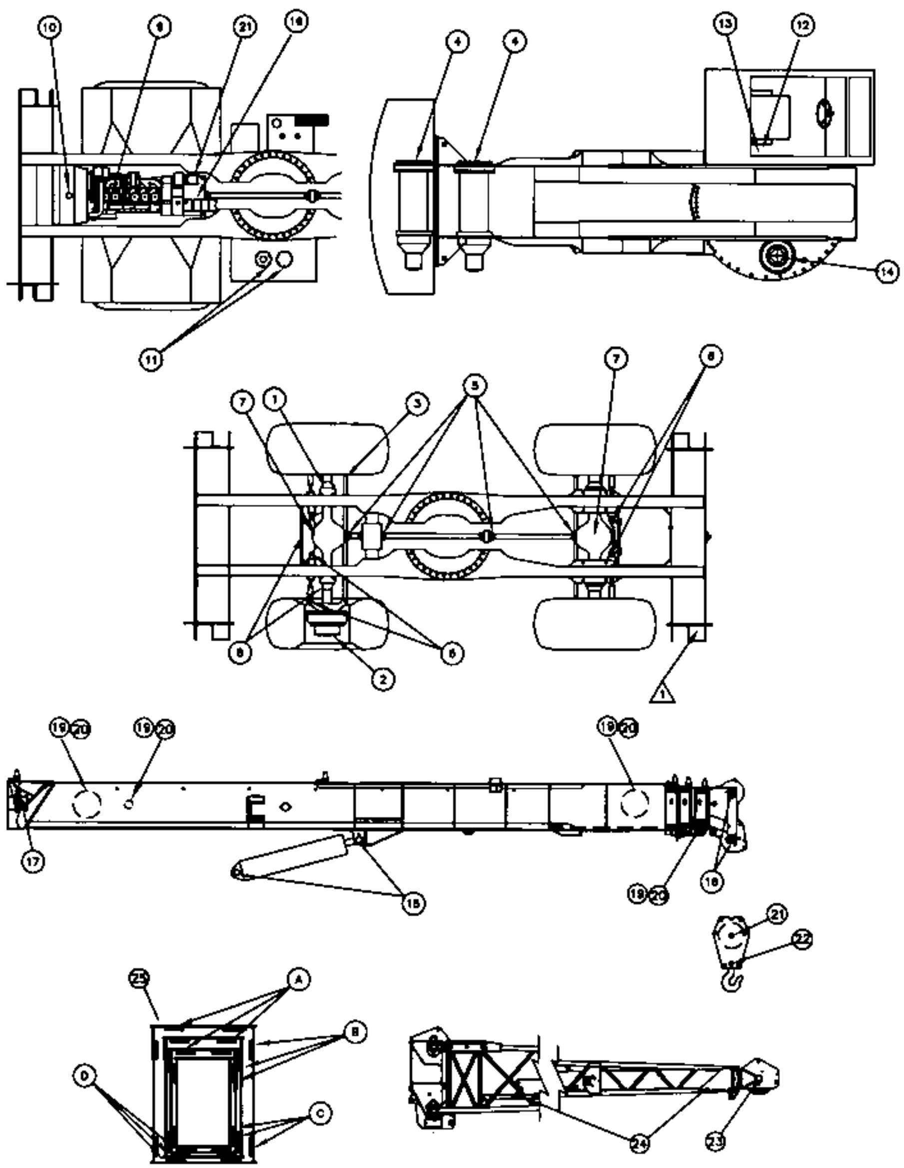


TABLE 1

LEGEND: D_DIPSTICK
CHK_CHECK
LUB_LUBRICANT
■_CHANGE FILTER
D/R_DRAIN & REFILL

*REFER TO OPERATORS MANUAL

DAILY (8 HOURS)	WEEKLY (40 HOURS)	TWO WEEKS (80 - 100 HOURS)	MONTHLY (100 - 200 HOURS)	THREE MONTHS (500 HOURS)	SIX MONTHS (1000 HOURS)	YEARLY (1000 - 2000 HOURS)	REF	DESCRIPTION	QUANTITY	NO.	LUBRICANT
	LUB						1	STEERING TRUNNION BEARINGS	PURGE	8	MPG
		INITIAL D/R	4 CHK		D/R		2	AXLE HUB DRIVE	FILL PLUG LEVEL	4	GL-5
	LUB						3	TIE ROD ENDS	PURGE	4	MPG
		INITIAL D/R		CHK	D/R		4	WINCH	APPR. 2 GAL	1	AGMA NO. 4EP
			LUB				5	DRIVE SHAFTS (TRAVEL - AXLES)	PURGE	6	MPG
	LUB						6	STEERING CYLINDER PINS	PURGE	4	MPG
		INITIAL D/R	CHK		D/R		7	AXLE DIFFERENTIALS	FILL PLUG LEVEL	2	GL-5
	LUB						8	AXLE PIVOT & CYLINDERS	PURGE	6	MPG
CHK #							9	CUMMINS QSB 5.9	14 QT + 1 QT FILTER	1	CONSULT ENGINE MANUFACTURER'S MANUAL
CHK							10	COOLING SYSTEM CAPACITY	48 QT	1	
CHK	INITIAL ■			■		D/R	11	HYDRAULIC RESERVOIR	HO - SEE TABLE 2 Keep Oil Level Between Marks		
	LUB						12	TURNTABLE GEAR **		2	GG (MPG BELOW 32°F)
		LUB					13	TURNTABLE BEARING RACE **	AS REQ'D	2	MPG BELOW 32°F: EP-1 ABOVE 32°F: EP-2
	CHK				D/R		14	SWING REDUCTION UNIT	11.5 PT.	1	SYNTHETIC GL - 5
	LUB						15	BOOM CYLINDER BUSHINGS	PURGE	4*	MPG
	CHK			■	D/R		16	TRANSMISSION & TORQUE CONVERTER	APPR. 4 GAL	2	-32°F & ABOVE: ATF
	LUB						17	BOOM PIVOT PIN	PURGE	2	MPG
	LUB						18	BOOM TIP SHEAVES	PURGE	7	MPG
	LUB						19	CHAIN ROLLER *	PURGE	4*	MPG
	LUB						20	BOOM EXTEND RETRACT CHAIN	AS REQ'D	4*	EO-SAE30 NON-DETERGENT
	LUB						21	HOOK BLOCK SHEAVES	PURGE	5	MPG
	LUB						22	HOOK BLOCK TRUNNION	PURGE	1	MPG
	LUB						23	JIB SHEAVE	PURGE	1	MPG
	LUB						24	JIB STINGER ROLLERS	PURGE	4	MPG
	LUB						25	BOOM SLIDE PADS (A,B,C,D) *	AS REQ'D	24	MPG
							26				
							27				
							28				
							29				
							30				

* See Operator's Manual.
** Apply lubricant while swinging the machine. See Operator's Manual
*** Change system oil & filter. See Operator's Manual.
• Lubricate Pads (A) thru access holes in boom and by applying grease to the top boom plate. Refer to Operator's Manual.
•• Lubricate thru front or rear access holes in axle housing. Move machine if necessary to access each fitting.

NOTE: Reduce all lubrication intervals under severe operating conditions. Refer to Operator's Manual for drain/refill procedures and additional information.

⚠1 Check outrigger booms daily and remove exess dirt.

TABLE 2

SPECIFIED LUBRICANTS			
MPG GG GL-5 SYNTHETIC GL-5 HO EO ATF	MULTI-PURPOSE GREASE OPEN GEAR GREASE GEAR LUBRICANT, EP GEAR LUBRICANT, EP HYDRAULIC OIL ENGINE OIL TRANSMISSION FLUID	EP-2 Grade 8 SAE 90 (Mil-L-2105B) SAE 75W90 *Koehring Spec. B05 A.P.I. Class as Listed Type C-3	*Refer to Operator's Manual for complete listing of recommended oils for applicable temperature ranges, and for drain & refill procedures.

PART NUMBER 12400-989

MAINTENANCE CHECKS

INTRODUCTION

A regular program of periodic preventive maintenence is essential to prolong crane operating life, maximize efficient service and minimize downtime. This section details a series of checks and procedures which are to be performed at daily, weekly, monthly and semi-annual intervals. These intervals are stated both in terms of calendar periods and hours of operation.

The checks prescribed for longer intervals include all the checks required for the shorter intervals. Thus, the weekly check includes all items in the daily check, the monthly check includes weekly and daily checks, and so on through the semi-annual check, which includes the quarterly, monthly, weekly and daily checks.

A convenient check chart provides a means of recording preventive maintenance performed and serves as a tool detecting problem areas and reanalyzing maintenance requirements. The items in each check interval on the check chart are grouped under their respective headings and covered in detail over the course of Section 6.

This maintenance schedule is a guide which ensures that basic preventive maintenance requirements will be met under average operating conditions. Conditions which impose greater wear, loads or strain on the crane may dictate reduced check intervals. Before altering the maintenance schedule, reevaluate crane operation and review the crane maintenance records. Consider all factors involved and develop a revised schedule adequate to meet routine maintenance requirements.

As a part of each periodic check, refer to the engine manufacturer's manual for engine maintenance requirements. When servicing the engine, the engine manufacturer's recommendations take precedence over those in this manual, should any discrepancy be noted.

OPERATOR OBSERVATION

As the operator, it is your responsibility to observe and report any unusual sounds, odors, or other signs of abnormal performance that could indicate trouble ahead. On a routine basis the following items should be checked before starting or while operating the crane.

Visual Inspection - Check complete machine for any unusual condition.

Check for any leaks or damage to the hydraulic system.

Check in the engine compartment:
* Belts for tension and wear
* Coolant level
* Oil level
* Transmission oil level
* Air cleaner sight gauge
* Air intake
* Muffler and exhaust

Check battery box - For battery condition

Crane boom - Check for:
* Hook block for wear or damage
* Two block system for proper function
* Cable and cable spooling on winch
* Cylinder pin connections for wear

Check tires, axles, and drive lines, for wear or damage.

Check in the cab for:
* Instruments functioning properly
* Control operation
* Glass for good visibility
* Safety equipment is ready for use
* All lights work properly
* Cleanliness - Free from mud and debris.

MACHINE MAINTENANCE CHECK LIST

DAILY CHECK (8 HOURS)

- ☐ Perform Daily Lubrication
- ☐ Check Hydraulic Reservoir Fluid Level
- ☐ Fill Fuel Tank
- ☐ Check Engine Oil Level
- ☐ Check Coolant Level
- ☐ Check Hydraulic Cylinder Mounting Bushings And Pins
- ☐ Check Hydraulic Components
- ☐ Check Transmission Oil Level
- ☐ Check Axle Lockout System
- ☐ Drain Fuel Filters or Water Separator
- ☐ Check Boom Front Slider Pads
- ☐ Drain Air Tanks
- ☐ Check Wire Rope And Related Components
- ☐ Check Air Cleaner
- ☐ Check Controls
- ☐ Check Instruments, Gauges, & Safety Equipment
- ☐ Make Overall Visual Inspection
- ☐ Torque Swing Bearing Bolts *
- ☐ Torque Wheel Nuts First 50 Miles*
- ☐ Check Anti-Two Block System
- ☐ Check Engine Manufacturer's Manual For Additional Maintenance Requirements
- ☐ Ensure Swing Brake Is Able To Hold Against Full Torque of Swing Motor

WEEKLY CHECK (40 HOURS)

- ☐ Perform The Daily Check
- ☐ Perform Weekly Lubrication
- ☐ Check Swing Reducer Oil Level
- ☐ Perform Initial Axle Oil Change*
- ☐ Check Axle Oil Level (after initial change)
- ☐ Check Battery Condition
- ☐ Check Tire Pressure and Condition
- ☐ Check Air System Safety Valve
- ☐ Check Hydraulic Cylinders and Rods
- ☐ Check Torque on Wheel Lug Nuts
- ☐ Make Thorough Inspection Of Wire Rope
- ☐ Make Initial Replacement Of Hydraulic Return Line Filter*
- ☐ Check Alcohol Evaporator Fluid Level
- ☐ Visually Inspect All Structural Members And Welds For Cracks, Alignment and Wear
- ☐ Check Boom For Wear, Cracked Welds, Alignment And Missing Or Illegible Decals
- ☐ Check Engine Manufacturer's Manual For Additional Maintenance Requirements
- ☐ Clean Machine Weekly If Salt Covered To Prevent Rust And Corrosion
- ☐ Check Torque on Wheel Lug Nuts

* Interval given applies only to initial period of use (break-in).

MAINTENANCE CHECKS

MONTHLY CHECK (160 HOURS)

- ☐ Perform Daily And Weekly Checks
- ☐ Perform Monthly Lubrication
- ☐ Check Engine Belts
- ☐ Drain Hydraulic Reservoir Of Moisture
- ☐ Obtain Hydraulic Oil Sample for Analysis.
- ☐ Clean Radiator Exterior
- ☐ Check Engine Manufacturer's Manual For Additional Maintenance Requirements

QUARTERLY CHECK (500 HOURS)

- ☐ Perform Daily, Weekly And Monthly Checks
- ☐ Perform Quarterly Lubrication
- ☐ Drain Fuel Tank Of Water And Sediment
- ☐ Change Transmission Filter
- ☐ Change Hydraulic Return Line Filters
- ☐ Replenish Cooling System Corrosion Inhibitor
- ☐ Check Engine Manufacturer's Manual For Additional Maintenance Requirements
- ☐ Lubricate Valve Disconnects
- ☐ Clean And Wax All Exterior Painted Surfaces

SEMI. ANNUAL CHECK (1000 HOURS)

- ☐ Perform Daily, Weekly, Monthly And Quarterly Checks
- ☐ Clean Crankcase Breather
- ☐ Clean Cooling System
- ☐ Check Reservoir Relief Valve
- ☐ Clean Reservoir Intake Suction Filter
- ☐ Change Transmission Oil
- ☐ Change Winch Oil
- ☐ Change Axle Oil
- ☐ Check Brake Shoes for Wear Condition
- ☐ Check Relief Valve Pressure Settings
- ☐ Torque Swing Bearing Bolts
- ☐ Check Engine Manufacturer's Manual For Additional Maintenance Requirements

OTHER INTERVALS

250 HOURS - CUMMINS ENGINE:
Change Engine Oil and Filter
Check Engine Air Intake
Change Engine Air Cleaner Element
Check Engine Drive Belt Tension

1500 HOURS: Drain And Clean Hydraulic Reservoir; Change Hydraulic Fluid

2000 HOURS/1 YEAR: Disassemble And Inspect Winch Components

SPECIAL BREAK IN REQUIREMENTS FOR NEW CRANES

8 HOURS - During the first 50 miles of service and any time the wheels have been removed, retorque the wheel nuts to 400-500ft. lbs.

40 HOURS - After forty hours of travel, drain and refill the transmission with new fluid.

40 HOURS - Retorque the swing bearing bolts to a torque of 600 ft. lbs. Recheck every 40 hours until all bolt are found properly torqued. Thereafter checks should be performed quarterly.

100 HOURS - After one hundred hours drain and change the winch lubricant.

100 HOURS - Retighten winch base mounting capscrews to 225 ft. lbs. of torque after one hundred hours of operation.

100 HOURS - Retighten counterweight capscrews to 845 ft. lbs.

⚠ CAUTION

All handles, steps, walkways and platforms must be kept free of grease, oils, fuel, mud snow and ice.

⚠ CAUTION

Sand-painted or other grit type anti-slip surfaces must be renewed when ever the surface begins to appear worn.

WIRE ROPE INSPECTION RECORD
(Refer to Wire Rope Users Manual For Criteria

PLACE OF INSPECTION ______________________ DATE ____________

DESCRIPTION OF CRANE

Make ______________ Model ______________ Serial No. ____________

Type and Arrangement of Attachments ______________________

DATE OF LAST ROPE INSPECTION ______________

HOURS AND TIME OF SERVICE SINCE LAST INSPECTION

RESULTS OF INSPECTION

Rope Inspected	Type and Size	Conditions Noted	Recommendations

INSPECTOR: ______________

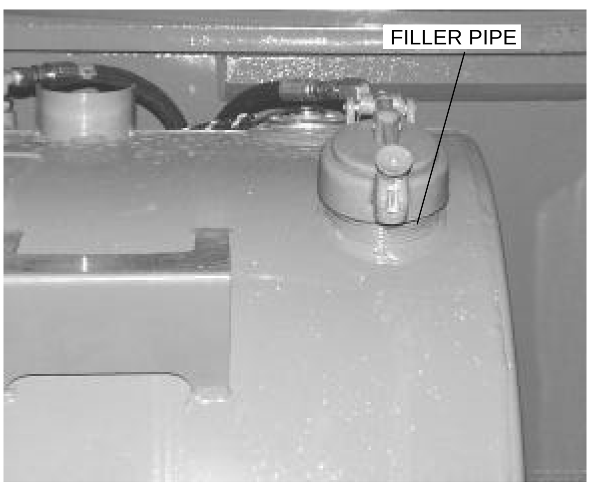
ENGINE MAINTENANCE

For Cummins engine maintenance refer to Cummins Operation and Maintenance Manual

Engine productivity, longevity, and low-cost performance depend on a regular program of periodic maintenance. The materials presented here are listed in accordance with the MAINTENANCE CHECK LIST in Section 4. Consideration may dictate a revision in scheduling for the periodic checks.

As a part of each periodic check, refer to the engine manufacturer's manual for engine maintenance requirements. When servicing the engine, the engine manufacturer's recommendations take precedence over those in this manual, should any discrepancy be noted.

DAILY:
FUEL LEVEL The fuel tank is located on the left side of the machine. Keep the tank as full as possible to minimize condensation in cold weather.



Use a good grade of No. 2 diesel fuel. The tank capacity is 80 gallons.

ENGINE OIL LEVEL The engine oil level is checked with the dipstick located on the left side of the engine (right side of machine). DO not check the oil level while the engine is running nor immediately after stopping the engine. For an accurate reading, allow 15 minutes for the oil to drain into the sump before checking. Keep the oil level as close to the full mark as possible. DO NOT OVERFILL

⚠ CAUTION

Never operate the machine when the oil is above the full mark or below the low mark.

WATER SEPARATOR
A water separator is used to remove water contamination from the fuel before it enters the engine. Water contamination should be drained daily or before it becomes 1/2 full.

AIR CLEANER Inspect the air cleaner and it's connections for leaks, dents and damage.

A vacuum actuated indicator mounted on the air cleaner assembly indicates conditions of restricted flow through the air cleaner. With the engine running at maximum governed rpm, observe the yellow band on the indicator piston. If the yellow band reaches the red band on the plastic cylinder, service is necessary. At this time, change the air cleaner filter element and clean the intake screen.

⚠ CAUTION

When using a degreasing agent to clean the engine, be sure to cover the vacuum actuated indicator (filter minder) with a protective material. Engine degreasing solvents have a polycarbonate base and can damage or destroy the indicator.

Reset the filter indicator each time the hood is opened as it provides a built-in check to assure proper functioning. If it does not reset then the orifice is plugged and must be cleaned.

A clogged filter restricts engine power output.

ENGINE BELTS Check all engine belts for condition and proper adjustment. Consult the engine manufacturer's manual for the recommended belt tension and tensioning methods.

QUARTERLY: Drain accumulated water and sediment from the fuel tank by removing the drain plug and allowing the tank to drain until all water is removed and the fuel flowing from the tank is free of sediment.

If a large amount of sediment has accumulated, drain the tank completely and flush liberally with kerosene until all sediment has been removed. Allow the tank to drain completely before refilling with fuel.

SEMI ANNUALLY:
CRANKCASE BREATHER Service the crankcase breather following the procedures given in the manufacturer's manual.

FUEL FILTER ELEMENTS On all machines with Cat engines, remove the fuel filter casings and replace the fuel filter elements every six months (1000 hours) or when there is evidence of plugging.

ENGINE RADIATOR MAINTENANCE

DAILY/8 HOURS:
COOLANT LEVEL Check the engine radiator coolant level and add coolant if necessary. The coolant should be visible in the sight gage near the top of the radiator tank. A solution of 50% ethylene glycol by volume is the recommended year-round coolant. Replenish the corrosion inhibitor if necessary. Refer to the "Operation Guide" supplied with the engine, or the nearest Engine manufacturer's service center for guidance in selecting the proper conditioner for the cooling system.

In climates where freezing does not occur, use a solution of clean water with a corrosion inhibitor for optimum cooling.

MONTHLY/160 HOURS:
RADIATOR EXTERIOR Clean any foreign matter from the radiator cooling fins and through-core cooling passages by directing compressed air and flushing water over the entire area of the core in the reverse direction of normal air flow.

QUARTERLY:
CORROSION INHIBITOR Replenish the cooling system corrosion inhibitor every 500 hours of operation.,

ATTENTION

Never use a chromate based inhibitor corrosion inhibitor when the cooling system contains ethylene glycol. Use only non-chromate based inhibitors. Chromate base inhibitors reacting with ethylene glycol can produce hydroxide, commonly known as "green slime". This substance reduces the heat transfer rate and can cause serious engine overheating.

SEMI ANNUALLY:
COOLING SYSTEM Clean the cooling system 1,000 hours or annually whichever comes first. Use a radiator cleaning compound, following the instructions on the container. Flush the system with fresh water and refill with an ethylene glycol solution of 50% by volume.

TRANSMISSION MAINTENANCE

WEEKLY MAINTENANCE CHECK On a weekly basis, check the TRANSMISSION OIL LEVEL.

Start the engine and run it at 1000 to 1500 rpm until the transmission reaches a normal operating temperature of (180° to 200° F.). Then idle the engine and shift through all range positions slowly. This will ensure that all parts of the system are filled with oil. Shift to neutral and set the engine speed at idle rpm.

SERVICING MACHINE AFTER TRANSMISSION OVERHAUL

When servicing the unit for the first time after vehicle installation and/or after repair, the unit is filled as follows:

A. Fill the unit with 5 gallons (18.9 liters) of the recommended lubricant.
B. Start the engine and run at idle speed to let the converter and oil lines fill.
C. Locate the oil level plug holes on the lower part of the transmission case on the right side of the machine. There are two 1/4 x 18 taper pipe thread oil level holes. The full oil level hole is 1 1/2 inches above the low oil level hole. Initially fill the transmission with oil until it flows out of the low oil level plug hole. Install the low oil level plug. Start and run the engine at idle speed to prime the converter, oil cooler, and lines. Recheck the oil level with the engine running at idle speed and bring level to the low oil level plug hole. When the oil temperature is stabilized at 180° to 200° F make final oil level check and bring oil level to the full oil level plug hole and install the oil level plug.

Note: The oil level is always checked with the engine running at idle speed, the transmission in neutral, and the oil temperature at 180 to 200° F. (82.2 to 93.3° C).

DO NOT OVERFILL THE TRANSMISSION.

Recommended Lubricant and Filter Change Intervals

Refer to page 4-10 for lubricant recommendations.

Recommendations utilizing the Dana-Clark Filter:

The lubricant and filter should be changed after the first 50 hours of transmission operation. After the initial lubricant and filter change, it is recommended that the filter be changed every 500 hours or 3 months of operation and the lubricant be changed every 1000 hours or 6 months of operation

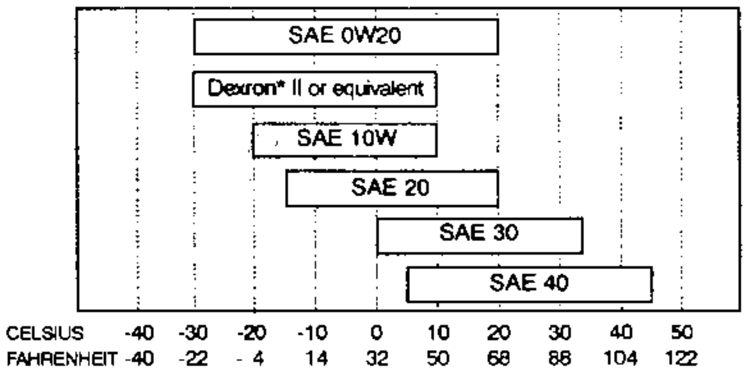
Note: In cold weather operation and/or initial start up (when the transmission oil is cold) the oil will have a higher viscosity which may allow the filter to bypass intermittently.

⚠ CAUTION

WHEN STALLING THE CONVERTER MAKE SURE THE TRANSMISSION IS IN HIGH GEAR, THE VEHICLE BRAKES SET, AND THE IMMEDIATE AREA IS CLEAR OF PERSONNEL AND OBSTRUCTIONS. DO NOT EXCEED 30 SECONDS OR 250°F CONVERTER OUT OIL TEMPERATURE, WHICHEVER COMES FIRST, AT FULL GOVERNED ENGINE RPM STALL SPEED.

TRANSMISSION

RECOMMENDED SAE J300 VISCOSITY GRADE BASED ON PREVAILING AMBIENT TEMPERATURE



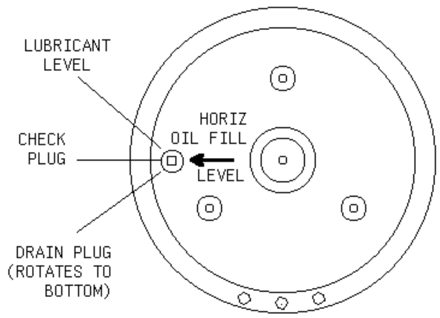
POWER SHIFT TRANSMISSION AND TORQUE CONVERTER HYDRAULIC FLUID ANALYSIS

Preferred lubricant specifications:

1. Caterpillar TO - 4
2. John Deere J20 C, D
3. Military MIL-PRF-2104G
4. Allison C - 4
5. Dexron II Equivalent

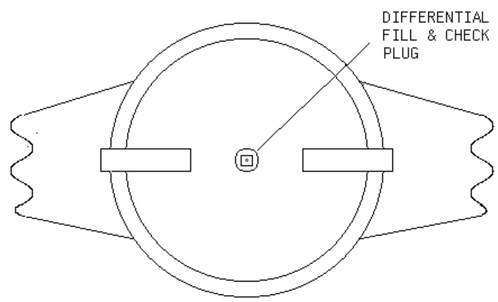
AXLE MAINTENANCE

MAINTENANCE CHECK As a part of the WEEKLY MAINTENANCE CHECK, inspect the axle and differential levels. When checking the AXLE OIL LEVEL, rotate each wheel until the planet cover is positioned as shown in the illustration below. the arrow on the planet cover points horizontal when the cover is properly positioned for checking the oil.



Remove the oil level plug in the planet cover and add oil as necessary to bring the oil level to the bottom of the fill and check hole See the lubrication chart.

Check the DIFFERENTIAL OIL LEVEL by removing the fill and check plug indicated in the illustration . Add oil as necessary to bring the oil level to the bottom of the hole. See lubrication chart.



On a SEMI-ANNUAL basis, drain the oil from the differential by removing the drain plug at the bottom of the differential housing. Replace the plug and refill the differential with the lubricant specified on the lubrication chart. To the level specified above.

Drain the oil from hubs removing the fill and check plug by rotating the hub until the hole is at the extreme low position. After draining, rotate the hub until the hole is at the check position. Refill the hub with the lubricant specified on the lubrication chart. Refill to the level of the bottom of the check plug.

TIRES

MAINTENANCE CHECK As a part of the WEEKLY MAINTENANCE checks, inspect the tires and rims for damage. Cuts and bruises, snags, punctures, and abrasions should be repaired before they can cause tire failure. Bent, cracked or loose rims should be repaired or replaced.

Check tire valve condition and make sure each valve has a cap.

Check the wheel retaining nuts for proper tightness. Wheel retaining nuts should be torqued to 400-500 ft.lbs.

TIRE PRESSURES Always maintain the recommended tire inflation pressures in all tires.

When driving, some increase in tire pressures can be expected due to heat generated by friction. Overspeeds may also produce increased tire pressures. In such circumstances, NEVER BLEEED THE TIRES. Instead slow down or stop until the tires cool.

Inflation pressure should be checked when tires are cool, using an accurate tire pressure gauge. Check pressures at regular intervals.

Bleeding the air from hot tires is dangerous and should not be attempted. While the pressure will be reduced, an increase in temperature of the tire will take place as soon as driving is resumed and tire failure will result.

UNDERINFLATION Too little air pressure increases deflection, causes the tread to wipe and scuff over the road, results in extra strain on the tire, and increases the chances for bruising.

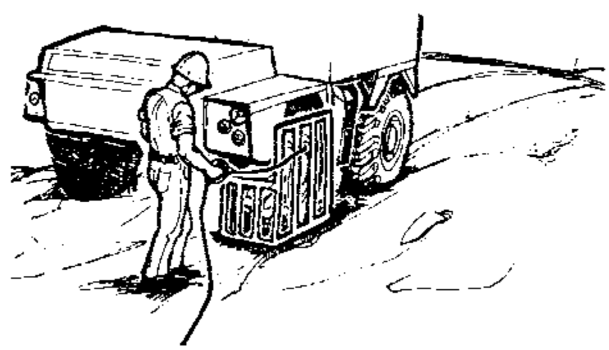
PROPER INFLATION Maintaining the proper air pressure provides maximum road contact and results in increased tire life.

OVERINFLATION Overinflation reduces tire deflection and tire contact area, causing the tire to ride on the crown, and results in rapid wear in the center of the tread.

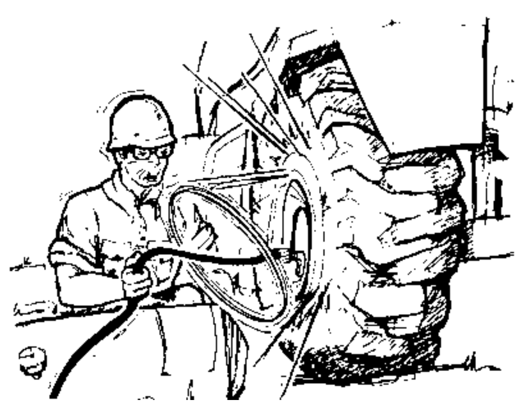
⚠ WARNING

The explosive stored in a tire and rim assembly under pressure makes changing truck and off-road tires hazardous. Death or personal injury can occur while handling or maintaining these tires. Special procedures must be followed and special tools must be used if tires are to be changed safely. Whenever possible, let your service company handle this job. If you must change a tire, follow the step by step instructions detailed in a tire repair manual. Should low pressures make it necessary to add air, never stand beside the tire tread. Instead use a extension hose long enough to permit you to stand behind the tire tread. Always use a tire cage or equivalent protection when adding air.

RIGHT WAY



WRONG WAY



SAFETY PRECAUTIONS
FOR MOUNTING OR DEMOUNTING
RIMS AND WHEELS

DO'S AND DON'TS

DO

1. Follow mounting and demounting procedures outlined in the manufacturer's instruction manual or other recognized industry instruction manual.
2. Deflate tires completely prior to demounting by removing the valve core.
3. Replace bent, cracked,worn, corroded, or damaged parts.
4. Double check to see that removable rings are seated properly before inflating.
5. Check for excessive side ring play and ring butting. Either one of these conditions is an indication of mismatched parts.
6. Inflate tires in a safety cage.
7. After inflating the tire, be sure that between a 1/16" minimum and a 1/4" maximum remains in a split ring or lock ring.
8. Inspect wheel nuts and rim clamps periodically for excessive wear, corrosion, proper centering and nut torque.

DON'T

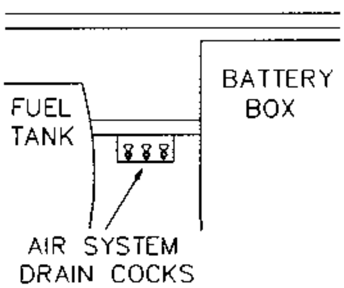
1. Don't use mis-matched parts. Mis-matched parts are dangerous. Make sure side ring and lock ring designations match those of the base.
2. Do not use loads or inflation pressures exceeding the manufacturer's recommendations.
3. Don't re-inflate a tire that has been run flat or seriously underinflated without first demounting and inspecting the tire and rim assembly.
4. Never use tire and rim combinations that are not approved by the Tire & Rim Association.

AIR SYSTEM MAINTENANCE

Inadequate delivery pressure or defective components operations can generally be traced to leakage, blocked lines, or the buildup of moisture and sediment in the system. A regular program of preventive maintenance is an essential part of air system operation. The materials presented here are listed in accordance with the MAINTENACE CHECK LIST in this section. Consideration of severe working conditions may dictate a revision in schedule periodic checks.

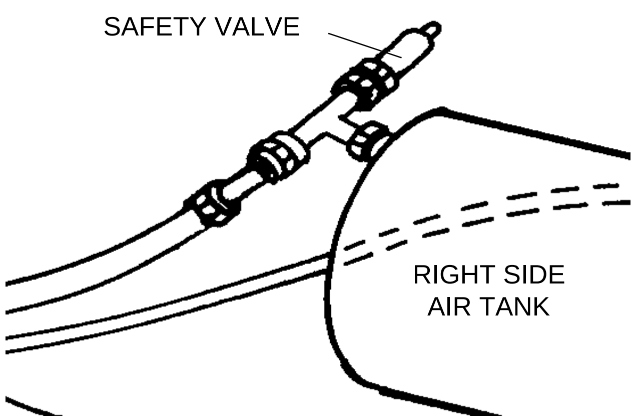
DAILY:

AIR TANKS Open the air tank drain cocks at least once daily to blow out moisture and accumulated sediment. The drain cocks are located on the frame rail by the battery box.



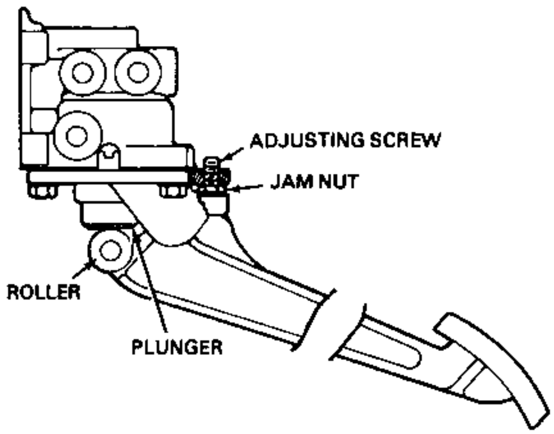
WEEKLY:

AIR SYSTEM SAFTY VALVE Manually actuate the air system safety relief valve by pushing in on the stem. This will ensure that the valve is not sticking. If the valve cannot be actuated in this manner, it should be repaired or replaced



BRAKE SYSTEM

BRAKE PEDAL:



MAINTENANCE Every 3 months or quarterly:

1. Lubricate fulcrum and roller pin with oil.

2. Free pedal travel should be checked as follows: Check to be certain plunger is in contact with spring seat. The stop button should be adjusted so that the roller and plunger just contact.

3. Apply oil or light grease between plunger and valve body. Do not overoil.

4. Clean exhaust check depending on type of service.

Every 12 months or annually:

1. Disassemble, clean parts with mineral spirits. Replace all rubber parts or any part worn or damaged. Check for proper operation before placing vehicle in service.

NOTE:

All rubber components in the treadle valve should be replaced yearly.

IMPORTANT!

An increase in stopping distance or a low pressure warning light indicated a malfunction in the brake system, and although the vehicle brake system may continue to function, the vehicle should not be operated until the necessary repairs have been made and both braking circuits are operating normally.

LEAKAGE CHECK

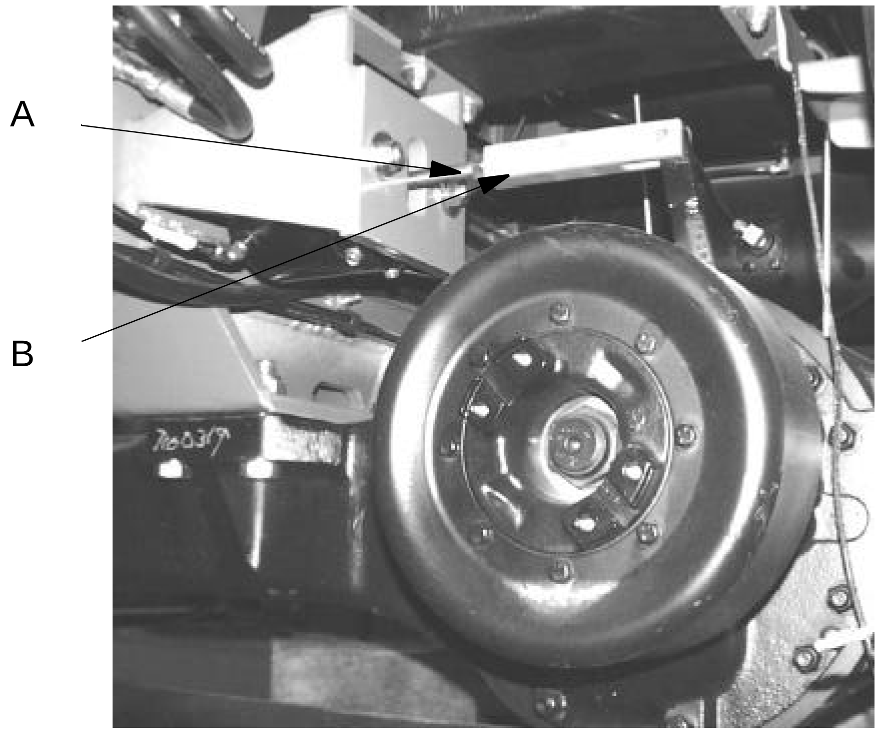
1. Make and hold full brake application.

2. Coat the exhaust port and body of the brake valve with soap solution.

3. Leakage is not to exceed a 1” bubble in 3 seconds in both the applied and released position.

If the brake does not function as described above or leakage is excessive, it is recommended that it be replaced with a new or remanufactured unit, or repaired with genuine Bendix parts available at Bendix outlets.

PARKING BRAKE



ROUTINE MAINTENANCE Under normal operating conditions the parking brake is maintenance free.

The parking brake is spring actuated. When the machine is operating and the brake is supplied with air pressure, it is released. If at, any point the machine loses air pressure (i.e. it is not running) the brake will be activated.

Adjustment is normally unnecessary.

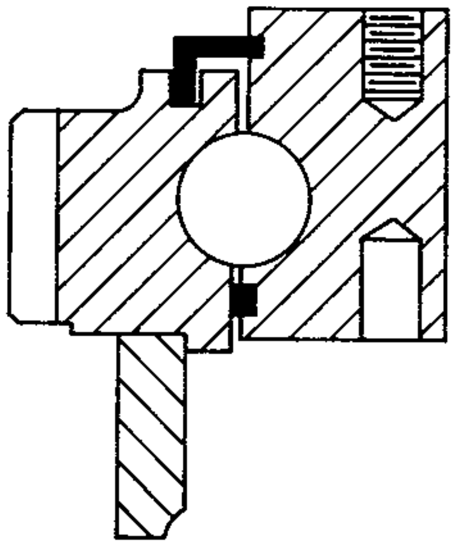
To confirm appropriate setting:

⚠ WARNING

Parts are under spring and air pressure. Also the machine must be running to confirm brake adjustment and you are adjusting the braking system. Chock the wheels before beginning the procedure.

Back off jam nut (A). This will free up the brake actuator yoke (B). Slide the yoke to the right as far as it will go. (This will be the point at which the drum and rotor contact. Then move the yoke 1/4” to the left and adjust jam nut until it is tight against the yoke.

TURNTABLE & SWING PINION



Lubricate every 100 operating hours as follows:

Inject grease as recommended below through one fitting located beneath an access panel in the operator's cab just behind the shift lever, as the machine is rotated at least two complete revolutions. When complete rotation is impractical, inject grease through each fitting and rotate machine back and forth as far as possible as each fitting is greased.

Under extremely dirty or dusty conditions, sufficient grease should be added to flush out contaminated grease. Under less severe conditions, add grease until it appears at the bottom seal.

While swinging the machine, apply gear grease to the external ring gear with sufficient frequency to insure that the teeth remain coated.

Some lubricants recommended by the manufacturer are:

	MOBIL	TEXACO	SUNOCO	AMOCO	EXON
RACE	Mobilux EP1	Mutifak EP1	Prestige 742EP	Amolith EP1	Beacon EP1
GEAR	Mobiltac 375NC	Crater 2X	407 Compound B	Amovis 8-X	Surett Fluid 4k

NOTE: Other manufacturers' lubricants of the same quality are suitable.

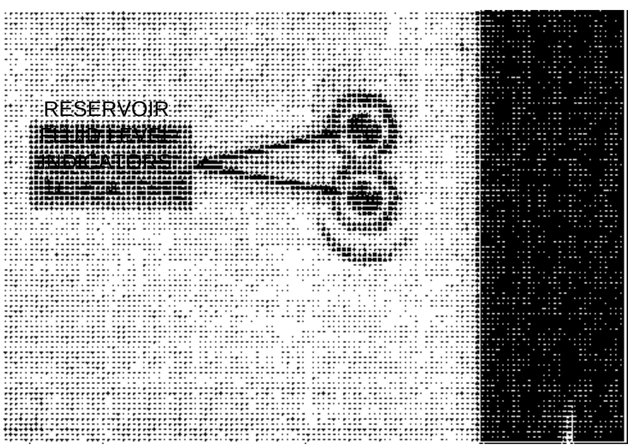
SWING REDUCER

MAINTENANCE CHECK On a WEEKLY basis, check the swing reducer oil level and add oil as needed to maintain the level at the “FULL” mark on the dipstick. Recommended lubricant is Sunep # 1060 or equivalent.

HYDRAULIC SYSTEM MAINTENANCE

MAINTENANCE CHECKS A regular program of periodic maintenance is an essential part of continued hydraulic system operation. Allowing accumulations of moisture and sediment to build-up in the system will damage hydraulic valves, pumps and motors. The presence of leaking connections or damaged components effect the efficiency of operation and are dangerous. The materials presented here are listed in accordance with the MAINTENANCE CHECK LIST. Consideration of severe working conditions may dictate a revision in scheduling periodic checks.

DAILY:
HYDRAULIC FLUID LEVEL The hydraulic reservoir, fluid level indicators, and filler cap are on the right side of the machine.



Retract all cylinders to return the maximum amount of oil to the reservoir and note the oil level indicators. The fluid level should be between the indicators. The top mark indicates system capacity with all cylinders retracted. Reservoir capacity is 179 gallons and system capacity varies with equipment up to a maximum of approximately 278 gallons.

Do not overfill.

Refer to Section 4, page 23 for hydraulic oils meeting the manufacturer’s specifications. Do not use oils which have detergent additives.

The hydraulic reservoir is sealed and has a 14 psi relief valve. Exercise extreme care when removing the filter cap. The pressure is relieved by turning the reservoir cap counterclockwise to the first stop. DO NOT turn the cap beyond the first stop until all pressure has been released. This will cause the cap to be blown off the reservoir with sufficient force to cause personal injury. DO NOT place any portion of your body above the reservoir cap while relieving the pressure or removing the cap.

HYDRAULIC COMPONENTS Check the hydraulic valves, motors, pumps, hoses, tubes and connections for excess dirt, oil and grease. Clean these items if necessary and check for leaks and damage. Tighten leaky connections and repair any damaged components.

WEEKLY:
RETURN LINE FILTER Change the hydraulic reservoir return line filters after the first 40 hours of the break-in period; thereafter follow the quarterly check recommendation.

MONTHLY:
HYDRAULIC RESERVOIR Drain any accumu- lated moisture from the hydraulic reservoir by parking the machine on a slight incline and loosen the pipe plug in the bottom of the reservoir.

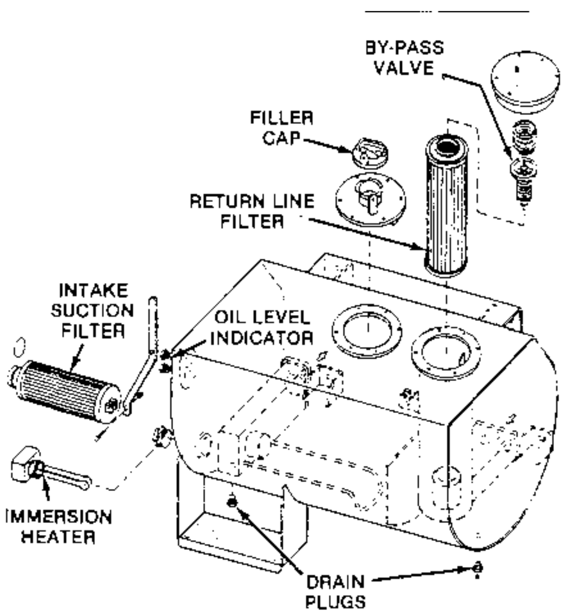
HYDRAULIC OIL Visually check the condition of the hydraulic oil once each month. Thickening of the oil or a change in its appearance, such as darkening, may serve as a rough indicator of when an oil change is needed. Periodic testing of the oil is the safest, most accurate method of determining the condition of the oil. An oil supplier can be consulted for assistance in testing the oil.

Change the oil whenever testing and/or inspection reveals the oil to be unsuitable for safe and efficient operation.

QUARTERLY:

HYDRAULIC FILTER Remove and replace the hydraulic reservoir return line filters. Access is gained by removing the cover plate on the reservoir.

When replacing the filters, clean the spring and bypass valves. Inspect the gasket for damage and replace if necessary.



Before discarding the old filter element, examine the type of material trapped in it. This may indicate which, if any, hydraulic system components are deteriorating.

SEMI ANNUALLY:

SUCTION FILTER Remove and clean the hydraulic reservoir intake suction filter. This per- manent screen type filter is located inside the reservoir on the intake to the pump manifold. Access to the filter is accomplished by removing the cover with filler neck and filter holding device from the top of the reservoir. Move the lever towards the front of the machine and lift out the filter.

Remove the “O” ring from the adapter and check it for damage or deterioration. If the ring is at all damaged, replace it.

Clean the filter by immersing it in a non-caustic cleaning solvent. Rub the screen surface with a soft brush to dislodge accumulated foreign matter. Reinstall filter, filter hold-down device and cover.

RESERVOIR RELIEF VALVE Check the hydraulic reservoir relief valve for proper functioning. The valve is located in the filler cap and is checked by extending all the boom cylinders and then retracting them to slightly pressurize the reservoir. When the cap is turned to the first notch, air should be heard escaping if the system is holding pressure. The system is sealed and has a relief valve pressure setting of 14 psi.

1500 HOURS:

HYDRAULIC RESERVOIR Drain and clean the hydraulic reservoir. Change the hydraulic oil.

A change interval cannot be established which would apply to all oils and all operating conditions of temperature and cleanliness. However, a reputable brand of turbine grade oil can be ex- pected to deliver 1500 hours of service under average operating conditions. Although conditions may necessitate shorter change intervals, do not use hydraulic oil for more than 1500 hours.

Whenever a visual inspection, chemical test or light test indicates that an oil change is necessary, proceed as follows:

1. Warm the oil prior to draining but avoid draining immediately after prolonged continuous use to reduce the danger of being burned by hot oil.

2. Retract all cylinders to return the maximum amount of oil to the reservoir. Loosen the top covers and remove the drain plug(s) at the bot- tom of the reservoir. Allow sufficient time for the reservoir to drain thoroughly.

3. Remove the return filters, clean springs, bypass valves and inspect cover gasket for damage and deterioration. Replace gasket if necessary.

A good lubrication program requires that all nor- mal wear points be lubricated according to a set schedule with specific types of lubricants. Refer to the lubrication chart and the special items covered in this section for the recommended lubricants, time intervals and lubrication procedures.

Where components such as the engine, transmis- sion and axles are not manufactured by this com- pany, the original manufacturer's recommendations take precedence should any discrepancy occur. If there is any doubt about the proper lubricants, intervals or lubrication procedures, refer to the original manufacturer's manual.

The lubrication intervals recommended in this section assume normal operating conditions. Where dust, dirt, high humidity or extreme heat are encountered, lubrication intervals should be shortened accordingly.

HYDRAULIC OIL REQUIREMENTS

The hydraulic system is filled with KOEHRING SPEC 805 hydraulic oil to give the unit the highest performance as a hydraulic machine and to provide proper lubrication for the hydraulic components. To ensure the longest life for this piece of equipment, particular attention must be paid to maintain oil at the proper level with an approved hydraulic oil and to keep the circuit system clean.

The oil for the hydraulic system performs the dual function of lubrication and transmission of power. Oil must, therefore, be selected with care and with the assistance of a reputable supplier. To guide in the selection of this oil, the general requirements are specified below. Good oils are economical in the long run. Check with the oil manufacturer prior to the use of his product.

Oils which conform to Koehring Specification 805 are recommended for most conditions. Under certain climate and operating conditions, it may be advisable to use a fluid of heavier or lighter viscosity in order to maintain a viscosity less than 7500 SSU at start-up and more than 50 SSU during operation. These machines should not be operated with hydraulic reservoir temperatures in excess of 200°F (87°C) due to possible excessive damage to the hydraulic oil and rubber components (hoses, seals, shaft seals, motor seals etc.). If over-heating occurs, discontinue operation and:

1. Check the hydraulic fluid level.

2. Check the oil cooler for cleanliness.

3. Check the oil viscosity versus the recommended Ambient Temperature may require an oil change.

4. Check the hydraulic system efficiency a pump may be failing or a relief valve set low.

5. Reduce the duty cycle of the machine.

6. Consult an authorized DISTRIBUTOR.

ENGINE OILS: Engine oils that meet Mil Spec 2104 and have the anti-wear additive zinc DO dithiophosphate can be used as hydraulic oils. NOT USE C.D. rated engine oil, some of which will not protect against wear in hydraulic pumps and motors.

ATTENTION

Not all motor oils have zinc dithiophosphate. Those that do not have this heavy duty additive can cause immediate failure of pumps.

Engine oils tend to form sludge in the presence of water. This sludge can plug the filters so they will require frequent changing. This is not detrimental to the machine unless the filters are allowed to plug so badly that they by-pass oil.

Never use multi-viscosity grades of engine oil because of the shear and thin out characteristics of this type of oil.

TRANSMISSION FLUIDS: DO NOT use transmission fluids. These fluids have been design- ed to work in automatic transmissions and they will not necessarily work in hydraulic systems.

MIXING: Mixing different brands of oil is not recommended. Various companies use different additive packages, which when mixed together, may cause problems in a hydraulic system. This type of problem is rare but can cause sludge which can plug the filters or acid which will etch the pump plates.

PRE-FILTER: Oil should be filtered through a 10 micron nominal filter before it enters the hydraulic system. New hydraulic fluid as received by the user is generally NOT in a satisfactory cleanliness condition for long component life.

OIL MAINTENANCE: Optimum life from hydraulic equipment can only be obtained with proper hydraulic oil maintenance. This includes checking the oil every three to six months. An oil should be checked for viscosity, oxidation, water content, contamination and copper particles. A record should be kept of each check to detect signs of progressive deterioration. Oil samples should be taken with the system running at normal operating temperature. It is important to use good technique in obtaining an oil sample. The exact same procedure should be followed each time an oil sample is taken. Most fluid suppliers will provide assistance in analyzing your oil sample. The following are some guidelines to use in this analysis.

Viscosity - Many hydraulic fluids will shear or thin out with use. The viscosity at each check should be compared to the viscosity when new. At no time should the viscosity be less than 45 SSU at 210°F. If viscosity is less than 45 SSU at 2I0°F, the oil must be replaced immediately.

Oxidation - Oil oxidation will occur with age and use and is evidenced by a change in color and/or odor, increased acidity, and possible formation of sludge, gum or varnish in the system. The rate of oxidation increases significantly with operations at temperatures over 140°F (60°C). The oil should be checked more often if operation is at high temperature. The oxidation process increases the acidity of the fluid and is measured by a neutralization number. The oxidation process is typically slow at first and then increases sharply in the final stages of complete oxidation. A sharp increase (by factor of 2-3) in a neutralization number is a good indication that the fluid is reaching the limit of its oxidation life and should be replaced.

Water Contamination - All hydraulic oils in the following charts will readily separate water which will settle to the bottom of the reservoir. This water should be drained off. The water that is measured in the oil sample will be dissolved water. This should be less than .05%. If it is greater than .05%, the oil in the system should be drained and replaced.

Particle Contamination - Excess contamination in a hydraulic system will greatly shorten the life of pumps and motors. Your oil sample analysis will show the number of particles per milliliter greater than a given micron size. The number of particles in your sample should be less than the following:

Particle Size	No. of Particles/Milliliter
10 micron or larger	3,000
20 micron or larger	300
30 micron or larger	100
40 micron or larger	30
50 micron or larger	10
100 micron or larger	1

If your oil sample shows numbers greater than in the chart, your hydraulic system is contaminated. The system should be checked for broken or torn filters, plugged filters, stuck filter bypass valves and so forth. Continued operation with particle counts greater than those shown in the chart will result in short pump and motor life.

Copper Particle Counts - The oil sample analysis should include a copper particle count in parts/million. This number should normally be less than 100. A high copper particle count indicates that a gear pump or motor is rapidly deteriorating. A count of 200 or more would be cause for concern. The most important thing to look for is a sudden increase in the copper particle count. This indicates that a gear pump or motor has suddenly begun deteriorating and a catastrophic failure can be expected shortly.

VISCOSITY: Oils are available in various grades (viscosities). The ISO (International Organization for Standardization) viscosity classification system is currently being adopted. The ISO grade applies strictly to viscosity and does NOT imply type of oil. (engine, antiwear, hydraulic, gear.etc.). A viscosity grade should be selected that will meet the minimum start up temperature requirement and the maximum operating hydraulic oil temperature.

ATTENTION

This machine is factory filled with Koehring spec 805 hydraulic fluid that is acceptable for start-up at ambient temperatures of 20°F and should not be operated above a hydraulic reservoir temperature of 200°F. If these limits are exceeded damage can result. For operation outside these ranges, select the proper hydraulic fluid from the charts on this and the following pages or from a reputable supplier.

HYDRAULIC OIL (Initial Fill)
KOEHRING SPEC 805 DATA

PHYSICAL PROPERTIES	TEST METHOD	REQUIRMENT
A. A.P.I. Gravity	ASTM D287	28 Min.
B. FLash Point	ASTM D92	380° F Min.
C. Viscosity Index 100°F 210°F	ASTM D445 ASTM D445	200-220 SSU 46 SSU MIn.
D. Viscosity Index	ASTM D2270	95 Min.
E. Pour Point	ASTM D97	-25° F Max.
F. Oxidation Test to 2.0 Neut. No.	ASTM D943 ASTM D943	2500 Hours Min. 2500 Hours Min.
G. Rust Test	ASTM D665 Procedure A	Pass
H. Foam Test	ASTM D892 Sequence l Sequence 11 Sequence lll	Foam Tendency — Foam Stability 25 ml Max. — Nil 50 ml Max. — 10 ml Max. 25 ml Max. — Nil
I. Demulsibility	ASTM D1401to 40-37-3 point	30 Min. Max.
J. Aniline Point	ASTM D611	200-230° F
K. Pump Wear	Dennison HFO or Vickers M2905 (100 Hrs.@150° F)	Satisfactory
L. % Zn	ASTM D1549	.07 Min.
M. Filterability		Fluid shall show no additive loss when filtered through 5.0 micron filter.
N. Cleanliness		Fluid shall appear bright and clear and shall be free of visible contaminants or sludge.

GRADE SELECTION CHART

Maximum life of pumps, motors, hoses, and seals will be obtained by selecting an oil as far down the chart as possible.

Viscosity Grade		Minimum Start-UP Temp. *	Ideal Cont. Operating Hyd. Oil Temp.	Maximum Operating Hyd. Oil Temp.	Selection Guide Lines
I.S.O. (New)	A.S.L.E. (Old)				
Synthetic		-30°F (-8°C)	160°F (71°C)	195°F (91°C)	Extreme cold start can be used year round in most machines in temperature climates
Multi. Viscosity		0°F (-17.8°C)	130°F (54°C)	190°F (88°C)	Cold Climate Year Round. Must Be Changed More Frequently Than Straight Grades
22		0° F (-17.8°C)	105°F (41°C)	160°F (71°C)	Winter Oil For Ambient Temperatures Up TO 60°F (16°C)
	150	5°F (-15°C)	120°F (49°C)	180°F (82°C)	For Ambient Temperatures Up To 80°F (27°C)
32		10°F (-12.2°C)	120°F (49°C)	180°F (82°C)	
	215	15°F (-9.4°C)	140°F (60°C)	200°F (93°C)	Can Be Used Year Round In Most Machines In Temperate Climates
46		20°F (-6.7°C)	145°F (63°C)	200°F (93°C)	
	315	25°F (-3.9°C)	155°F (68°C)	200°F (93°C)	Well Suited For Most Machines In Southern U.S. And As Summer Oil For Heavily Loaded Machines In Central And Northern U.S.
68		30°F (-1.1°C)	160°F (71°C)	200°F (93°C)	
100		35°F (-1.1°C)	175°F (80°C)	200°F (93°C)	Especially Suited For Regions With Ambient Temp. Range From 100°F To 120°F

* Minimum temperature for starting without extended warm-up. For lower temperatures, follow warm up procedure in the operators manual.

PREMIUM GRADE ANTI-WEAR HYDRAULIC OILS

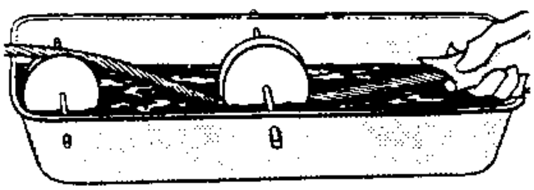
OIL COMPANY	ISO	BRAND NAME
Amalie Refining Co. (USA)	32 46 68 100	Ama-Oil R&O 100 AW Ama-Oil R&O 200 AW Ama-Oil R&O 300 AW Ama-Oil R&O 500 AW
Amoco Oil Co. (USA)	32 46 68	Amoco AW 32 Amoco AW 46 Amoco AW 68
Arco	32 46 68 100	Duro AW 32 Duro AW 46 Duro AW 68 Duro AW 100
Conoco	 32 46 68 100	Conoco DN 600 (Artic) Conoco Super Hyd. 5W-20 (Multi Vicosity) Conoco Super Hyd. 32 Conoco Super Hyd. 46 Conoco Super Hyd. 68 Conoco Super Hyd. 100
D-A Lubricant Co. Inc (USA)	32 46 68 100	D-A Hydra Shield 32 D-A Hydra Shield 46 D-A Hydra Shield 68 D-A Hydra Shield 100
Dryden Oil Co. (USA)	32 46 68 100	Paradene Anti-Wear 32 AW Paradene Anti-Wear 46 AW Paradene Anti-Wear 68 AW Paradene Anti-Wear 100 AW
Exxon Co. (USA)	32 46 68 100	Nuto-H 32 Nuto-H 46 Nuto-H 68 Nuto-H 100
Gulf Oil Co. (USA)	32 46 68 100	Gulf Harmony AW 32 Gulf Harmony AW 46 Gulf Harmony AW 68 Gulf Harmony AW 100
Imperial Oil Limited (Canada)	32 46 68 80 100	Nuto H 32 Nuto H 46 Nuto H 68 Nuto H 80 Nuto H 100

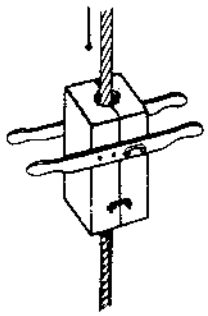
OIL COMPANY	ISO	BRAND NAME
Kendll Refining Co. (USA)	32 46 68 100	Kenoil R&O AW 32 Kenoil R&O AW 46 Kenoil R&O AW 68 Kenoil R&O AW 100
Mobil Oil Corp.	32 46 68	DTE 24/DTE-13M DTE 25/DTE-15M DTE 26/DTE-16M
Northland Products (USA)	32 46 68 100	Talamar 150 Talamar 215 * Talamar 315 Talamar 465
Pennzoil Products Co. (USA)	 32 46 68 100	AWX Multi-Viscosity AW 32 Hyd. Fluids AW 46 Hyd. Fluids AW 68 Hyd. Fluids AW 100 Hyd. Fluids
Shell Co. (Canada)	37	Tellus T37 (Multigrade)
Shell Co. (USA)	23 32 46 68 100	Tellus 23 Tellus 32 Tellus 46 (XSL 9101) Tellus 68 Tellus 100
Sun Oil Co. (USA)	32 46 68 100	Sunvis 816 WR Sunvis 821 WR Sunvis 831 WR Sunvis 851 WR
Texaco Inc. (USA)	 32 46 68	Rando Oil HD A2 (5w-20) Rando Oil HD 32 Rando Oil HD 46 Rando Oil HD 68

*** Factory filled with Northland Talamar 215 or equivalent.**

KOEHRING SPEC 805 IS EQUIVALENT TO HYDRAULIC OILS SHOWN ABOVE

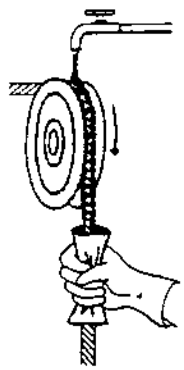
Hot Application

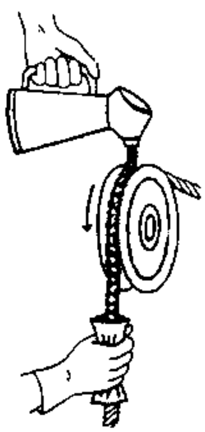




Continuous Bath

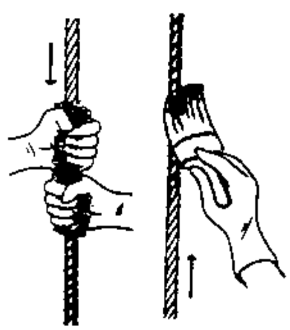
Dripping

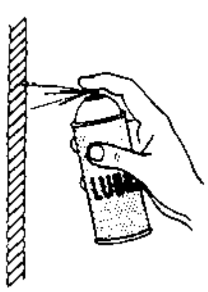




Pouring

Swabbing
And Painting





Aerosol Spraying

CABLE LUBRICATION METHODS

GENERAL We are covering the more commonly used methods of lubricating cable (wire rope). For special cable lubrication problems consult the cable manufacturer.

HOT APPLICATION A heated bath is placed in the path of the wire rope, and the rope is passed through the hot lubrication over sheaves and a center guide wheel. Hot oils or greases have excellent penetrating qualities and upon cooling have high adhesive and film strength around each wire.

CONTINUOUS BATH Run an operating rope through a specially constructed casing that has been packed with swabbing and loaded with lubricant. This affords continuous lubrication.

DRIPPING A container can be placed above the sheave, so that the rope can be lubricated by opening a spigot. Sheaves are the best location for lubricating operating wire ropes, because the wires and strands open somewhat as they bend along the groove.

POURING Lubricant can be poured on. The rope should be lightly loaded and run slowly while being lubricated.

SWABBING AND PAINTING Lubricant can be swabbed on with rags, or painted on with a brush. Both are quick methods which can be made part of the operating routine.

SPRAYING A light lubricant containing solvents can be applied to a wire rope by a properly directed spray nozzle.

AEROSOL SPRAYING Installations requiring only small amounts of lubricants, or only occasional applications, may find the new aerosol cans of lubricant useful. They are available from several lubricant manufacturers.

ELECTRICAL SYSTEM
BATTERY CHECK

MAINTENANCE CHECK Observe all instruments and gauges while operating machine and carrying out your DAILY MAINTENANCE checks. Replace or repair any malfunctioning instruments or gauges.

BATTERY The maintenance free battery is located under the battery cover on the left hand side of machine. Use maintenance free battery charging information.

A maintenance-free battery does not require the addition of water during its life in normal service. This is due to the fact that maintenance-free bat- teries produce little gas at normal charging voltages.

TESTING MAINTENANCE-FREE BATTERIES

CAUTION

Whenever the battery is placed on charge. Wear safety glasses. Do not break “live” circuits at the battery terminals. Maintenance-free batteries of the latest design incorporate flame arrester vents to reduce the possibility of explosions caused by external sparks. Therefore, during charging, the vents, if removable, should remain in place. A wet cloth should be placed over the vent openings as an additional precaution.

Step 1 - Visual Inspection- Visually inspect the outside of the battery for obvious damage such as a cracked or broken case or cover which would allow electrolyte loss. Check for terminal damage. If obvious physical damage is found, replace the battery. If possible, determine the cause of damage and correct.

Check the condition and size of the cables. Are the cable clamps tight? Check for corrosion on the terminal or clamps. Clean corroded parts and/or tighten clamps if necessary. Replace badly corroded cables or cables with defective terminals. Make certain the negative cable is making a good connection where it is grounded to the engine and the positive cable to. the starter relay. If the “Visual Inspection” is satisfactory, proceed to Step 2.

Step 2 - Electrolyte Levels And State Of Charge - Check the electrolyte level in the cells if possible. The level can be seen through translucent plastic cases. It can also be checked in batteries which are not sealed. If the electrolyte level is below the tops of the plates in any cell, add water if the vents are removable. If the battery is sealed, and water cannot be added to it, replace the battery and check the charging system for a malfunction such as a high voltage regulator setting. Follow instructions of manufacturer if the battery has a special indicating device.

If the level is O.K., unknown or water can be add- ed to the battery, and the stabilized open circuit voltage is below 12.4 volts, charge the battery as described under “Charging”. The voltage is stabilized if the battery has stood overnight without being charged or discharged. If the battery has been on charge, the voltage can be stabilized by placing a 15 ampere load across the terminals for 15 seconds. Another method of stabilization is to turn on the headlamps for 15 seconds. Read the voltage at least three minutes after the discharge load is removed. When a hydrometer reading can be taken, a value of 1.225 @ 80°F (26.7°C) can be used instead of the 12.4 voltage reading. If the battery has a test indicator follow the instructions of the manufacturer. After the battery is recharged, stabilize the voltage as described above, then proceed to Step 3.

If the stabilized voltage of the battery was above 12.4 volts when it was first examined, or the test indicator indicated the battery is charged, proceed to Step 3 without charging the battery.

Step 3 - Load Test Procedure - The load test procedure is conducted to determine if the battery requires recharging or replacement.

A. Disconnect the battery cables (ground connection first) and connect the voltmeter and load test leads to the battery terminals, making sure the load switch on the tester is in the "OFF" position.

B. Apply a test load equal to 1 /2 the Cold Cranking Amperes @ 0°F (-l8°C) Rating of the battery, for 15 seconds. (Example: a battery has a Cold Cranking Rating @ 0°F (- 18°C) of 350 amperes. Use a test load of 175 amperes.)

C. Read the voltage at 15 seconds and remove the load. If the voltage is less than the minimum specified in the "Voltage Chart" (see "Maintenance-Free Battery Testing Chart", in Troubleshooting section) replace the battery. If the voltage meets or exceeds the specified minimum, clean and return battery to service.

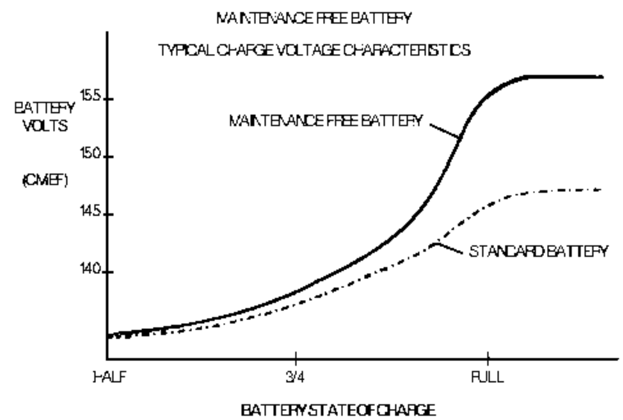
If the state of charge of a battery cannot be determined and the battery fails the load test, it must be recharged and retested. If it meets the specified voltage on the second test return it to service. If it does not meet the specified voltage on the second test, replace the battery.

The above is a standard test procedure to determine the ability of a battery to function properly. If a commercially available tester is being used to analyze the battery, follow the instructions of the equipment manufacturer.

CHARGING MAINTENANCE-FREE BATTERIES

Maintenance-free batteries contain sulfuric acid and generate explosive hydrogen and oxygen gases the same as all lead acid batteries. No one should charge a battery unless they have been thoroughly instructed concerning the step by step procedures to use and the safety precautions to take.

It must be realized that maintenance-free batteries cannot be charged at ampere rates or periods of time greater than specified in the "12-Volt Maintenance-Free Battery Charging Guide". If the battery is charged more than specified, it loses water which cannot be replaced in some constructions so the life of the battery is shortened. Battery chargers for maintenance-free batteries should include a charge duration control of some sort. The simplest control is a timer which the operator sets. Voltage controls can limit the charge more consistently and accurately. Such controls also may have a safety feature that prevents sparks and reverse charging when the clamps are connected in reverse, by mistake.



Place a wet cloth over the vent opening or openings. If, when charging the battery, violent gassing or spewing of electrolyte occurs, or the battery case feels hot (125°F, 52°C), reduce or temporarily halt charging to avoid damaging the battery.

Follow the manufacturer's instructions on the charger. If they can no longer be read and a copy of them is not available, write to the manufacturer for a copy and paste it on the charger. Never use a charger without these instructions.

Always turn the charger to the "OFF" position before connecting the leads to the battery. If you have any doubts that the charger is actually "OFF", disconnect it from the power source.

The state-of-charge of maintenance-free batteries can be determined with an accurate voltmeter. A voltmeter should not be used unless it can be checked frequently against one of known accuracy. If the stabilized voltage of a battery at room temperature is 12.2 volts, is should be charged for one-half the time shown in the "Slow Charge" column of the Charging Guide, at the applicable rate in amperes. If the voltage is 12.4 volts, it should be charged for one-fourth the time shown in the "Slow Charge" column, at the applicable charging rate. Follow the manufacturers instructions on batteries equipped with state-of-charge indicators.

Any battery which is known to be discharged or has a stabilized voltage below 12.2 volts should be charged as shown below.

12-VOLT MAINTENANCE-FREE BATTERY CHARGING GUIDE

Battery Capacity (Reserve Minutes)	Slow Charge
Above 125 to 170 Minutes	20 Hours @ 5 Amps 10 Hours @ 10 Amps

NOTE: If a battery is to be charged overnight, (16 hours) a timer or voltage controlled charger is recommended. If the charger does not have such controls, a 3 ampere rate should be used for batteries of 80 minutes or less capacity and 5 amperes for above 80 to 125 minutes reserve capacity batteries. Batteries over 125 minutes should be charged at the specified SLow Charge rate.

BOOST CHARGE If a battery requires a boost charge, it should be charged at 45 amperes for 20 minutes. This cannot be used for a new battery being prepared for installation.

MODIFIED CONSTANT POTENTIAL TAPER CHARGING It is recommended that maintenance-free batteries be recharged on a modified constant potential taper chargers. The total charge must not exceed the ampere-hour equivalent of the values shown in the “Charging Guide”. It is recommended that the initial charging rate not exceed 30 amperes.

ELECTRICAL SYSTEM COLLECTOR RING

ELECTRICAL COLLECTOR RING When troubleshooting the electrical system, always check the collector ring first to see that the spring-loaded brushes are centered in the bands. Keep free of any foreign material.

Keep the set screws on the collector ring tight. Otherwise the wire harness may wrap up as the machine is swung.

The cover should allow for free operation of the collector ring and the brake. If linkages bind, erratic operation may result. Check for unrestricted operation.

COLLECTOR RING MAINTENANCE If not revolved for some time, under some conditions, the ring will have a tendency to collect fine silt, or salt atmosphere will cause corrosion. If this happens, the crane should be rotated through several revolutions if possible. The cleaning action of the brushes should clean the ring surfaces. If it does not, or it is not practical to revolve the machine, it may be necessary to use a standard non-residue solvent to clean the ring. Then lightly sand the brushes and rings with a fine grade of sandpaper and dust off with compressed air.

MAINTENANCE CHECKS On a daily basis, inspect the cylinder mounting brackets, bushings, and pins for wear, tightness and damage. If misalignment or excessive play or wear are detected, replace the defective pin or bushing. Check the rod eye welds for cracks and breaks.

Inspect the hydraulic cylinder rods for nicks, dents, and scoring as part of your WEEKLY MAINTENANCE check. Also check the cylinders for leaks at the wiper seals. Repair or replace any damaged components.

MAINTENANCE CHECK Every TWO YEARS OR 4000 HOURS disassemble and inspect the winch components. These include the gearing, bearings, and brake friction discs. Refer to the Service Manual for disassembly procedures.

LUBRICATION Lubrication for the winch is provided by weepage flow from the drive motor. Oil enters the final drive end through the drive shaft tube in the drum. A drain line on the main drive end cover returns excess oil to the reservoir.

CABLE REEVING

CABLE REEVING When reeving the machine for any job, remember that hoisting and lowering speeds decrease as the number of parts of line increases. For the most efficient use of the machine, it is desirable to use the minimum number of required parts for lifting the anticipated loads.

CAUTION

Never use less than the number of parts called for by the load rating chart. The minimum required - number of parts is determined by referring to the load rating chart.

This machine incorporates a “Quick Reeving” boom head and block which do not require removal of the wedge and socket from the rope in order to change the reeving. Removal of two pins in the boom head and three in the hook block will allow the wedge and socket to pass through.

CAUTION

NOTE: If a socket is changed or replaced, or if you are changing hook block weights, it is IMPORTANT to use the correct socket.

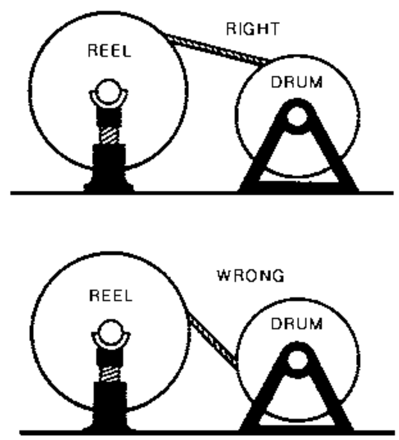
SPOOLING WIRE ROPE ON DRUMS

Care must be exercised when installing wire rope on the winch drum. Improper spooling can. result in rope damage through crushing, kinking, dog- legs, abrasion and cutting. Poorly installed wire rope will also adversely affect the operating characteristics of the machine by causing uneven application of force and motion. This, in turn, can cause premature fatiguing and failure of the rope.

Thoroughly inspect and clean the winch before proceeding with the installation. Check the lagging and drum flanges for cracks, breaks and excessive wear. Deformed or outsized drum and excessive undercutting at the base of the flange also indicate that repair or replacement of the drum is necessary.

Check the bearings for excessive wear and play.
After correcting any defects revealed by the inspection and determining that the winch is in good operating condition, spool the wire rope as follows:

Mount the cable shipping reel vertically on jacks or a suitable supporting structure, with a pipe or bar through the reel center. The cable should be drawn from the top of the reel, as shown, in order to avoid reverse bending as it is spooled onto the
If cable is wound from the storage reel onto the drum, the reel should be rotated in the same direction as the hoist.



Apply braking force to the reel flange in order to prevent overrun as the rope is being drawn off. Loops formed by overrun can cause kinks and doglegs in the rope, resulting in damage and premature rope failure. A timber or block forced against the shipping reel flange can be used to provide the required braking force.

WIRE ROPE AND REEVING

MAINTENANCE All wire ropes in active service should be inspected DAILY along with spooling, sheaves, wedge sockets, and any other wire rope fittings for damage. Once WEEKLY a through wire rope inspection should be made by a competent inspector. A record should be kept of the inspections on 4-5.

Refer to Wire Rope Users Manual, section 9 and ANSI Standard B30.5 for guidelines covering the inspection, maintenance, repair, and replacement of wire rope. Worn, kinked, birdcaged, fatigued or otherwise damaged wire rope must be removed immediately. Wire rope when properly installed, lubricated and employed, will give many hours of satisfactory use. Whereas, a new piece of wire rope can be immediately ruined if misused.

CRUSHED ROPE
REMOVE AT ONCE!

KINKED ROPE
REMOVE AT ONCE!

BIRD CAGING
REMOVE AT ONCE!

Replace or repair any items found to be in unsatisfactory condition.

In addition to damage such as kinking, crushing and broken wires, factors such as corrosion, abrasion, pitting, peening and scrubbing of the outside wires, reduction of rope diameter, the condition of other components and proper lubrication are considered. Refer to page 4-26 for wire rope lubricating procedures.

Before installing a new or replacement rope, make certain the rope to be used is the proper type and size. The wrong rope will not function properly and may even be dangerous.

WIRE ROPE SPECIFICATIONS

MAIN WINCH

STD. - 3/4" 6X19 OR 6X37 IPS IWRC
PREFORMED RIGHT REG. LAY WIRE ROPE
WEIGHT 1.04 LBS/FT
MINIMUM BREAKING STRENGTH - 25.6 TONS

OPT. - 3/4" ROTATION RESISTANT
34 X 7 COMPACTED STRAND, GRADE 2160
WEIGHT 1.24 LBS/FT
MINIMUM BREAKING STRENGTH - 34.5 TONS

AUXILIARY WINCH

STD. - 3/4" 6X19 OR 6X37 IPS IWRC
PREFORMED RIGHT REG. LAY WIRE ROPE
WEIGHT 1.04 LBS/FT
MINIMUM BREAKING STRENGTH - 25.6 TONS

OPT. - 3/4" ROTATION RESISTANT
34 X 7 COMPACTED STRAND, GRADE 2160
WEIGHT 1.24 LBS/FT
MINIMUM BREAKING STRENGTH - 34.5 TONS

⚠ CAUTION

Terex permits the use of rotation resistant wire rope, other types are not approved. When this rope is used the working load shall not exceed 1/5th (20%) of the rated breaking strength. The retirement criteria shall be as follows: two broken wires in six rope diameters or four broken wires in thirty rope diameters.

Install cable on the winch drum in accordance with the following procedure.

1. Position the cable over the boom tip sheave and route back to the winch drum.

2. Position the winch drum with the cable anchor slot on top.

3. Insert cable through slot and position around the cable wedge.

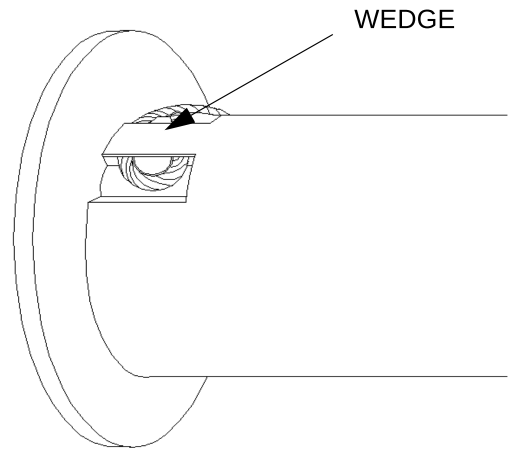
4. Position the anchor wedge in the drum slot; pull firmly on the free end of the cable to secure the wedge.

5. Slowly rotate the drum, ensuring the first layer of cable is evenly wound on the drum.

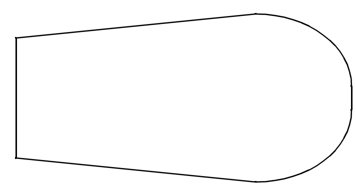
6. Install the remainder of the cable, as applicable.

The end of the cable should be even with the bottom of the anchor wedge.

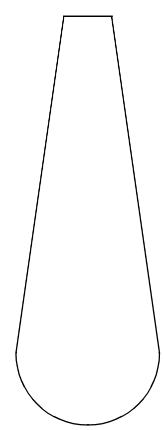
NOTE: If the wedge does not seat properly in the slot, carefully tap the top of the wedge with a mallet.



WINCH DRUM WEDGES

WHERE USED	PART NUMBER	
MAIN WINCH	216529	
AUXILIARY WINCH	216529	

CABLE SOCKETS AND WEDGES

WHERE USED	PART NUMBER	
3/4" CABLE SOCKET & WEDGE 3/4" SOCKET WEDGE	1234-44 218534	

CAUTION

The wrong cable wedge could permit the wire rope to work lose and detach itself from the drum; possibly causing property damage or personal injury.

Tension the wire rope by braking the shipping reel and slowly operate the winch in the raise mode to wind the cable onto the winch drum. As the spooling proceeds, make sure the adjacent turns are tight against one another. A lead or brass hammer may be used to tap the rope over against preceding turns. Tight winding on the drum is absolutely essential.

CAUTION

Never use a steel hammer or pry bar to move the rope over on the drum. These tools can easily damage the rope.

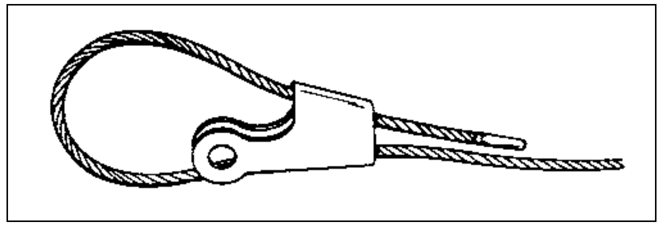
After the rope is wound onto the winch drum, reeve the cable as desired.

CAUTION

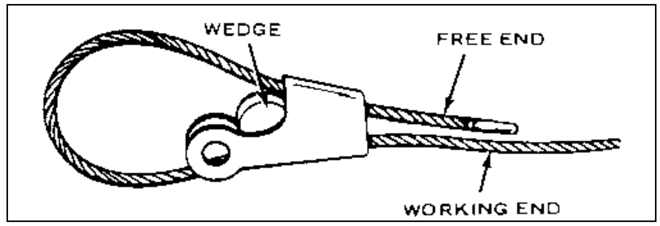
Use only factory supplied sockets, wedges and pins of the proper size; make no substitutions.

Follow the procedure below when installing wedge type sockets on wire rope. Be certain the correct socket and wedge are used.

1. Lead the rope through the socket, form a large loop and draw the rope end back through the socket. A length of rope equal to at least one rope lay should be drawn back through.

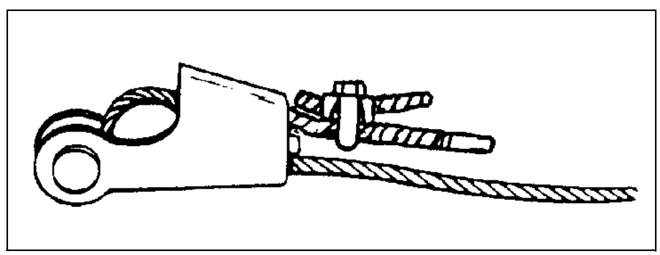


2. Insert the wedge and allow the rope strands to adjust around it.



3. Seat the wedge and loop just tightly enough to allow handling by attaching the socket to a strong support and engaging the winch to take a strain on the rope.

4. Final seating of the wedge is accomplished by making lifts of gradually increasing loads. avoid imposing shock loads on the rope until the wedge is firmly in place.



5. After the wedge has been firmly seated, a short length (6 inches) of the cable should be secured to the free end of the wire rope to act as a stop as shown. DO NOT clamp the free end to the load supporting end as this will weaken the rope.

CRANE BOOM

WEEKLY:

STRUCTURAL MEMBERS AND WELDS Visually inspect all structural members and welds including (but not limited to) the extended boom for straightness, roller (or pad) adjustment, and cracks. Pay special attention to the longitudinal welds joining the top, side and bottom plates. Check the welds attaching the jib ears to the boom head and the welds attaching the boom head to the tip section. Inspect the cylinder attaching supports and the boom pivot area.

On the superstructure, inspect the superstructure as well as the welds on the hoist cylinder supports and the welds between the bottom mounting plate and the vertical plates. This is especially important if the machine is being used extensively in clamshell, pile driving, concrete pouring, headache ball, or other high duty cycle applications.

On the carrier, inspect the swing bearing weld band and supporting header welds. Check the outrigger attaching welds, outrigger box ends at the collar, jack cylinder mounting tube, and the beam welds.

BOOM Visually inspect all boom sections a minimum of weekly or every fifty (50) hours, whichever occurs first. Preparatory to making the inspection, set the outriggers and rotate the upper to an area where the boom can be fully lowered and extended.

With the boom fully lowered and extended, visually inspect the sides, top and bottom of each section for any unusual deformation, scrubbing, wear, or cracking in either the plates or welds, particularly the fillet welds along the bottom edge of the side plates of the telescoping sections. In addition, note any missing or illegible indicator mark decals on the telescoping sections.

WARNING

If any cracks in either fillet welds or plates are noted, the particular component must be replaced before any further crane operations are performed. This is necessary to maintain the structural strength of the boom and prevent possible catastrophic failure resulting in injury or property damage.

Field repair of boom sections is NOT recommended because distortion may be introduced and original structural strength not restored.

Boom extension indicator decals are extremely important and must be maintained in place at all times. Boom section failures can occur due to overstressing within rated capacities if the sections are not equally extended within one indicator mark difference between the telescoping sections.

NOTE: Sections are equalized byfully extending or fully retracting the boom. When the boom reaches either full extension or retraction continuing to hold the telescope lever in the extended or retracted position will allow the boom sections to be proportioned equally.

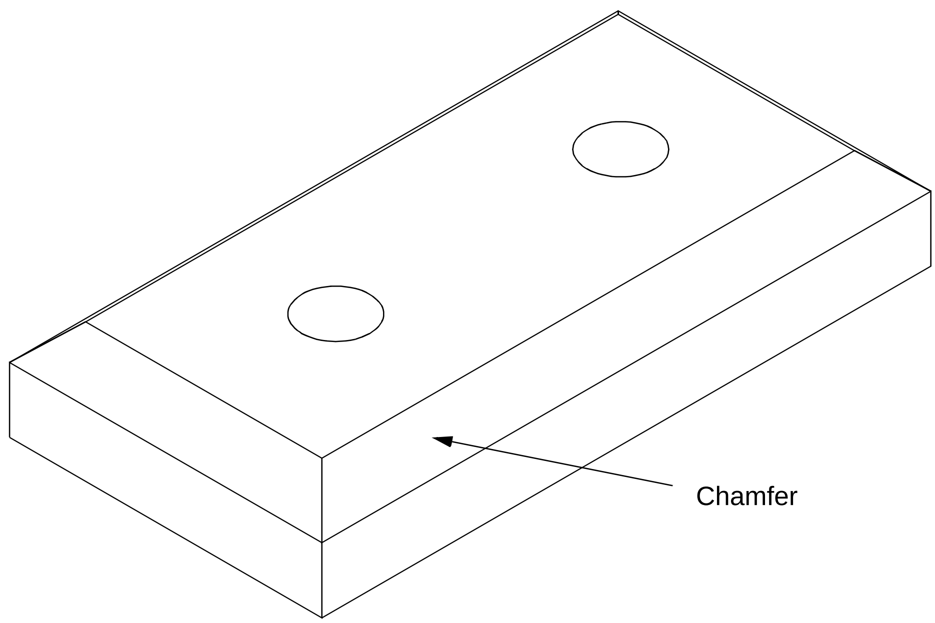
If any indicator decals are missing or illegible (either triangle markers or boom length numbers), order the applicable items through your distributor and apply them using the dimensions given on the following page.

AIR DRYER

Desiccant cartridge life will vary depending on operating conditions, speeds, loads, air usage and compressor condition. It is recommended that the desiccant cartridge be replaced approximately every 2 years. If system performance is reduced, desiccant cartridge replacement is necessary. It is also recommended that the desiccant cartridge be replaced if the compressor has been rebuilt.

SLIDER PADS

The front bottom slider pad should be checked daily for wear. The remainder of the slider pads should be checked monthly for wear.



All the slider pads contain a chamfer on the wearing surface. When this chamfer is worn off, the slider pad must be replaced.

With boom extended brush grease on areas of boom where wear pads contact is evident. he inside of the top plate of all sections except the tip section also require grease. This can be applied through the holes in the side plates and “piled” on top of the next section out just in front of the top rear pads on that section so that extending the boom to the next hole smears the grease onto the inside of the top plate. Remember to do both sides.

Grease intervals vary and should be more frequent if noise or jerking of the boom is evident.

INDEX

SECTION 5

SUBJECT **PAGE**

As the operator, it is your responsibility to detect any unusual, sounds, odors, or other signs of abnormal performance that could indicate trouble ahead.

By detecting any problems in their early stages, you can save yourself unnecessary downtime and your employer a lot of money! Therefore, it is also your responsibility to use good judgment in detecting failures in quickly and repairing them. If you don't, one failure can lead to another.

Before attempting to make an adjustment yourself, ask yourself if you have the RIGHT TOOLS, IF you have the PROPER TEST EQUIPMENT and IF you can accurately DIAGNOSE the cause of the problem.

If you can't answer YES to all three questions, rely on your Distributor Serviceman. He has the right tools, testing equipment and service knowledge to pin-point the problem in minutes instead of the hours consumed in hit-or-miss methods. TIME IS MONEY! He will save it for you.

If you decide to attempt an adjustment yourself, follow a logical TROUBLE SHOOTING PROCEDURE. Don't simply replace parts until the trouble is found.

GENERAL PROCEDURE

1 - KNOW THE SYSTEM Study this manual and learn what makes the machine "tick", how it should behave, sound and smell.

2 - OPERATE THE MACHINE Test operate all machine functions. Note all abnormal sounds, odors and movements. Always proceed in the most logical order to determine the cause.

3 - INSPECT THE MACHINE Look for leaks, listen for the source of abnormal sounds, detect the origin of unusual odors. Check the condition of the oil and filters.

4 - LIST THE POSSIBLE CAUSES Use your best judgment in listing all possible causes of the failure.

5 - REACH A CONCLUSION Review your list of possible causes and decide which are the most likely to cause the failure. Consider the most obvious first.

6 - TEST YOUR CONCLUSION Test your conclusions, in order of obviousness, until the source of the failure is found. The machine can then be repaired at minimal cost and downtime. Make the repair. Recheck to ensure that nothing has been overlooked, functionally test the repaired part in the system.

7 - REVIEW MAINTENANCE PROCEDURES Prevent recurrences of all premature failures by regularly checking the filters, temperature, adjust- ments and lubrication. Make daily inspections.

NOTE: Your safety and that of others is always the number one consideration when working around cranes. Safety is a matter of thoroughly understanding the job to be done and the application of good common sense. It is not just a matter of "do's" and "don'ts". Stay clear of all moving parts.

HYDRAULICS - GENERAL

Before any troubleshooting is attempted, become fully acquainted with the following two (2) basic fundamental facts of a hydraulic system:

1 - SPEED The speed of a hydraulic function is directly related to the system flow. A reduction in speed of a cylinder or motor is caused by an insufficient quantity of oil being delivered to the component.

2 - POWER The power or force of a hydraulic function is related to pressure.

If an understanding of the differences between speed and power of a hydraulic system is under- stood correctly, then accurate troubleshooting can be accomplished in a minimum amount of time.

⚠ WARNING

NEVER resort to increasing the valve relief pressure in an attempt to cure the ills of the system. Fully diagnose the problem.

Hydraulic components are precision units and their continued smooth operation depends on proper care. Therefore, do not neglect hydraulic systems. Keep them clean and change the oil and oil filter at established intervals.

If, in spite of these precautions, improper opera- tion does occur, the cause can generally be traced to one of the following:

1. Use of the wrong viscosity or type of oil.
2. Insufficient fluid in the system.
3. Presence of air in the system.
4. Mechanical damage or structural failure.
5. Internal or external leakage.
6. Dirt, decomposed packing, water, sludge, rust, etc., in the system.
7. Improper adjustments.
8. Oil cooler plugged, dirty or leaking.

Whenever hydraulic, fuel, lubricating oil lines, or air lines are to be disconnected, clean the adjacent area as well as the point of disconnect. As soon disconnected, cap, plug or tape each line or opening to prevent the entry of foreign material. The same recommendations for cleaning and covering apply when access covers or inspection plates are removed.

Clean and inspect all parts. Be sure all passages and holes are open. Cover all parts to keep them clean. Be sure parts are clean when they are installed. Leave new parts in their containers until ready for assembly.

Clean the preservative compound from all machined surfaces of new parts before installing them.

OPERATOR - CONTROLS

NO MOVEMENT OF THE FUNCTION

Check to see that valve spool actuates when control is operated.

If spool shifts, refer to sections on 1) Relief Valve Troubleshooting; 2) Motor, Cylinder or Winch Troubleshooting according to circuit being checked; 3) Pump Troubleshooting; 4) Control Valve Troubleshooting.

WITH THE ELECTRICALLY CONTROLLED VALVES on the outriggers, three (3) spools must be checked.

The diverter valve should be checked by using a test gauge on the test port and activating the outrigger controls. If pressure (2500 psi) is indicated, the spool is shifting.

Check the outrigger extend-retract and function valves by pushing the. pins in prior to activating the functions. Check to see if the appropriate pin has been pushed back out as the functions are activated. If they have, the spools are shifting.

If the spools do not all shift, check the electrical connections. Frequently ground connection are a problem.

If no electrical power is present at the valve, check the electrical wiring and correct the fault. Most controls require a minimum of 10 volts.

If power is present, repair or replace the solenoid or valve section which is not shifting.

If the spools shift, see page 5-19, “Outrigger Cir- cuit”.

AXLES

RAPID OR UNEVEN TIRE WEAR

CAUSE	REMEDY
Incorrect toe-setting	**Check and reset toe-in if necessary.**
Improper tire inflation	**Inflate to proper pressure.**

HARD STEERING

CAUSE	REMEDY
Inadequate or improper lubrication of knuckle pins	**Consult lubrication chart for proper lubricant, lubrication intervals and procedures.**
Overloaded Axle	**Reduce load.**

RAPID WEAR OF TIE ROD ENDS

CAUSE	REMEDY
Inadequate or improper lubrication	**Consult lubrication chart for proper lubricant, lubrication intervals and procedures.**
Severely contaminative environment	**Clean and lubricate more often.**

AXLES

BENT OR BROKEN TIE ROD, STEERING ARM, TIE ROD ARM, OR BALL STUD

CAUSE	REMEDY
Excessive power steering pressure	**Check steering pump relief setting, check steering system relief setting; adjust as required.**

HEAVILY WORN STEERING ARM BALL STUD

CAUSE	REMEDY
Inadequate or improper lubrication	**Consult lubrication chart for proper lubricant, lubrication intervals and procedures.**

EXCESSIVE WEAR OF KNUCKLE PINS AND BUSHINGS

CAUSE	REMEDY
Inadequate or improper lubrication	**Consult lubrication chart for proper lubricant, lubrication intervals and procedures. Increase lubrication frequency when operating in extrem conditions.**

STEERING CIRCUIT

Most steering problems can be corrected if the problem is properly defined. The entire steering system should be evaluated before removing any components. The steering control unit is generally not the cause of most steering problems. The following is a list of steering problems along with possible causes and suggested corrections.

SLOW STEERING, HARD STEERING, OR LOSS OF POWER ASSIST

-CAUSE-	-REMEDY-
Worn or malfunctioning pump	Replace pump.
Stuck flow divider piston	Replace flow divider.
Malfunctioning relief valve allowing the system pressure to be less than specified	Replace the relief valve.
Overloaded steer axle	Reduce load.
Leaking or kinked load sensing signal line	Correct.
Malfunctioning priority valve	Check spring and sticking piston. Check damping orifices in both ends of main bore. Check adjustment See page 5-6. Check system pressure at SCU inlet for proper system pressure. If not correct replace priority valve relief cartridge.

WANDER
VEHICLE WILL NOT STAY IN A STRAIGHT LINE

-CAUSE-	-REMEDY-
Air in the system due to low level of oil, cavitating pump, leaky fitting, pinched hose, etc	Correct.
Worn mechanical linkage	Repair or replace.
Bending of linkage or cylinder rod	Repair or replace.
Loose cylinder piston	Repair or replace.
Severe wear in steering control unit	Replace the steering control unit.

DRIFT
VEHICLE VEERS SLOWLY IN ONE DIRECTION

-CAUSE-	-REMEDY-
Leaking cylinder seals	Reseal cylinders.
Worn or damaged steering linkage	Replace linkage and align front end.

SLIP
A SLOW MOVEMENT OFSTEERING WHEEL FAILS TO CAUSE ANY MOVEMENT OF STEERED WHEELS

-CAUSE-	-CAUSE-
Leakage of cylinder piston seals or accessory valve between cylinder lines or ports	Replace seals or accessory valve.
Worn steering control unit meter	Replace steering control unit.

TEMPORARY HARD STEERING OR HANG-UP

-CAUSE-	-REMEDY-
Thermal Shock*	Check unit for proper operation and cause of thermal shock.

ERRATIC STEERING

-CAUSE-	-REMEDY-
Air in system due to low level of oil, cavitating pump, leaky fitting, pinched hose, etc	Correct condition and add fluid.
Loose cylinder piston	Replace cylinder.
Thermal shock damage*	Replace steering control unit.
Sticking flow control spool	Replace flow control valve.

“SPONGY” OR SOFT STEERING

-CAUSE-	-REMEDY-
Air in hydraulic system. Most likely air trapped in cylinders or lines	Bleed air out of system.
Low fluid level	Add fluid and check for leaks.

FREE WHEELING
STEERING WHEEL TURNS FREELY WITH NO FEELING OF PRESSURE AND NO ACTION ON STEERED WHEELS

-CAUSE-	-REMEDY-
Steering column upper shaft is loose or damaged	Tighten steering wheel nut.
Lower splines of column may be disengaged or broken	Repair or replace column.
Steering control unit meter has a lack of oil. This can happen on start-up, after repair, or long periods of non use	Usually starting engine will cure problem. If not, stop engine, discon nect steer pump outlet hose and pour in hydraulic oil to prime pump.
No flow to steering unit can becaused by:	
1. Low fluid level	Add fluid and check for leaks.
2. Ruptured hose	Replace hose.
3. Internal steering control unit damage due to thermal shock*	Replace the unit.

FREE WHEELING STEERING WHEEL TURNS WITH SLIGHT RESISTANCE BUT RESULTS IN LITTLE OR NO STEERED WHEEL ACTION

-CAUSE-	-REMEDY-
Piston seal blown out	Determine cause. Correct and replace seal.

EXCESSIVE FREE PLAY AT STEERING WHEEL

-CAUSE-	-REMEDY-
Loose steering wheel nut. Steering column shaft worn or damaged. There should be very little free play in the unit itself.	Repair or replace steering wheel connection or column.

EXCESSIVE FREE PLAY AT STEERED WHEELS

-CAUSE-	REMEDY-
Broken or worn linkage between cylinder and steered wheels	Check for loose fitting bearings and anchor points in steering linkage between cylinder and steered wheels.
Leaky cylinder seals	Replace cylinder seals.

BINDING OR POOR CENTERING OF STEERING WHEEL

-CAUSE-	-REMEDY-
Binding or misalignment in steering column or splined input connection	Align column pilot and spline to steering control unit.
High back pressure in tank line can cause slow return to center. Should not exceed 300 psi	Check circuit return line for blockage.
Large particles can cause binding between the spool and sleeve	Clean unit and filter oil. If another component has failed, generating contaminents, flush system while bypassing steering control unit.

STEERING UNIT LOCKS UP

-CAUSE-	-REMEDY-
Large particles in meter section	Clean the unit.
Insufficient hydraulic power (units over 15 in^3)	Check hydraulic power supply.
Severe wear and/or broken pin	Replace the unit.
Thermal shock*	Replace the unit.

STEERING WHEEL OSCILLATES OR TURNS BY ITSELF

-CAUSE-	-REMEDY-
Parts assembled wrong. Steering unit improperly timed.	Correct timing.
Lines connected to wrong ports	Reconnect lines correctly.
Leaking seal in rotary manifold	Reseal.

STEERED WHEELS TURN IN WRONG DIRECTION WHEN OPERATOR ACTIVATES STEERING WHEEL

-CAUSE-	-REMEDY-
Lines connected to wrong cylinder ports	Reconnect lines correctly.
3-way steering valve malfunctioning	See “Operator Controls”.
Cab facing toward rear reverses response	Be alert when operating with cab over rear.

STEERING WHEEL KICKS AT START OF STEERING

-CAUSE-	-REMEDY-
No inlet check valve on steering control unit	Install a check valve.

ALTERNATOR

OPERATION NOISY

CAUSE	REMEDY
Worn or dry bearings	**Replace worn bearings.**
Alternator mounting loose	**Tighten alternator mounting.**
Belt loose	**Replace worn belt or tighten loose belt.**
Brush holders out of alignment	**Replace brush holders.**
Brushes not seated properly	**Reseat or replace brushes.**
Armature unbalanced	**Replace armature.**
Commutator out-of-round	**Dress commutator.**
Loose windings	**Replace defective windings.**
Armature rubbing	**Replace bearings.**

EXCESSIVELY HIGH ALTERNATOR ELECTRICAL OUTPUT

CAUSE	REMEDY
Alternator regulator out of adjustment	**Replace regulator.**
Field leads shorted.	**Replace or repair alternator.**
Alternator regulator shorted	**Replace regulator.**

ALTERNATOR MECHANICALLY INOPERATIVE

CAUSE	REMEDY
Belt loose	**Tighten belt.**
Armature shaft sheared	**Replace or repair alternator.**

LOW OR NO ALTERNATOR ELECTRICAL OUPUT

CAUSE	REMEDY
Field coil open	**Replace or repair alternator.**
Brushes dirty, worn, pitted, or burned	**Replace or repair alternator.**
Alternator regulator defective	**Replace regulator.**
Alternator to regulator field leads open or connections loose	**Tighten connections or replace field leads.**

ALTERNATOR OVERHEATS

CAUSE	REMEDY
Loose or worn belt or pulley	**Adjust belt, or replace worn belt or pulleys.**
Misalignment	**Inspect mounting brackets and tension adjusting arm for looseness. Tighten or replace parts as required.**

STARTER

STARTER INOPERATIVE

CAUSE	REMEDY
Commutator dirty	**Clean commutator.**
Brushes worn	**Replace brushes.**
Starter relay malfunctioning	**Repair or replace relay.**
Pinion spring broken or weak	**Replace or repair starter.**
Frame housing defective	**Replace or repair starter.**

BRAKES

INSUFFICENT BRAKE ACTION

CAUSE	REMEDY
Worn brake linings	**Replace brake pads.**
Blocked, bent, or broken tubing or hose	**Remove obstructions in line or replace faulty tubing.**
Brake valve delivery pressure below normal	**Clean and replace worn parts if brake valve is defective, replace unit.**
Insufficient parking brake valve delivery pressure	**Clean and replace worn parts, or if valve is defective, replace unit.**

BRAKES RELEASE TOO SLOWLY WITH PEDAL RELEASED

CAUSE	REMEDY
Weak or broken valve diaphragm return spring	**Replace brake valve.**
Relay or quick-release valve exhaust ports obstructed	**Clean or replace faulty unit.**

ONE BRAKE DRAGS WITH PEDAL RELEASED

CAUSE	REMEDY
Brake pad binding	**Remove pad, clean and lubricate**
Weak or broken brake shoe return springs	**Replace faulty spring**

BRAKES ACT UNEVENLY OR GRAB WHEN PEDAL IS DEPRESSED

CAUSE	REMEDY
Grease or oil on linings	**Clean linings or replace linings or pad assemblies.**
Defective brake valve	**Replace faulty unit.**
Brakes need relining	**Replace brake pads.**
Brake chamber diaphragm leaking	**Tighten all fittings; if caused by broken or faulty unit, replace the unit.**

PARKING BRAKE

PARKING BRAKE WON'T APPLY

CAUSE	REMEDY
Restricted hose or tube	**Remove restriction or replace.**
Defective relay valve	**Repair or replace.**
Defective spring brake valve	**Repair or replace.**
Defective control valve	**Repair or replace.**

PARKING BRAKES WON'T RELEASE

CAUSE	REMEDY
Insufficient system air pressure	**Allow engine to run to increase pressure to above 70 p.s.i.**
Restricted hose or tube	**Remove restriction or replace.**
Insufficient hold off pressure	**Check for system (or excessive valve) leaks.**
Leaking brake actuator diaphragm	**Replace brake actuator (spring pot).**
Defective relay valve	**Repair or replace relay valve.**
Defective spring brake valve	**Repair or replace spring brake valve.**
Defective control valve	**Repair or replace control valve.**

AIR PRESSURE

INADEQUATE AIR PRESSURE

CAUSE	REMEDY
Leaks in system	**Repair leaks.**
Frozen lines	**Thaw out lines.**
Defective compressor	**Inspect for sticking unloader valve, replace if necessary.**
Reservoir leaking	**Replace.**
Tank to compressor supply line damaged	**Replace.**

SWING CIRCUIT

SWING COMPLETELY INOPERATIVE

CAUSE	REMEDY
Mechanical swing lock applied, if equipped	**Disengage the swing lock.**
Swing brake applied	**Disengage the swing brake.**
Spring brake stuck in applied position	**Disassemble swing brake and free-up unit.**
Swing valve main relief valve stuck in open position	**See section on "Relief Valves".**
Swing motor leaks excessively internally	**See section of "Fluid Motor".**
Mechanical fault in swing reducer gear box or swing bearing	**Repair swing reducer or replace swing bearing.**
Hose plugged or liner collapsed	**Replace hose.**
Rotary manifold leaking internally	**Reseal rotary manifold.**
Swing pump faulty	**See section on "Pumps".**

SWING MOTION SLUGGISH

CAUSE	REMEDY
Main relief valve stuck in open position	**Replace.**
Faulty swing pump	**Repair or replace swing pump.**
Swing motor leaks excessively, internally	**Replace or reseal motor.**
Excessive leakage around swing control valve spool	**Replace or replace control valve.**

SWING MOTION ERRATIC

CAUSE	REMEDY
Brake not releasing completely	**Check operation of swing brake and/or swing lock.**
Low hydraulic oil level	**Add oil as required.**

SWING MOTION ERRATIC (CONTINUED)

CAUSE	REMEDY
Swing bearing not lubricated properly	**Lubricate swing bearing.**
Main relief malfunctioning	**See section on "Relief Valves".**

BOOM HOIST CIRCUIT

BOOM DRIFTS DOWN

CAUSE	REMEDY
Hold valve not seating properly	**Replace hold valve.**
Hoist cylinder by-passing	**See section on "Cylinder Leakage".**

BOOM HOIST ONLY - INOPERATIVE OR ERRATIC

CAUSE	REMEDY
Boom will drift down	**Repair or replace hold valve.**
Boom won't lower	**Repair, replace, or backflush hold valve.**
Boom hoist cylinder binding	**Repair or replace.**
Load is too great	**Consult capacity chart, check RCI.**
Piston packings damaged	**Replace packings.**
Low oil level	**Add oil as required.**
Hose plugged or liner collapsed	**Replace hose.**
Air in cylinder	**Bleed cylinder.**

BOOM DROPS SLIGHTLY AS RAISE CONTROL IS RELEASED

CAUSE	REMEDY
Air in cylinder	**Bleed cylinder.**
Boom hoist hold valve free flow check not seating properly	**Replace hold valve.**

BOOM HOIST AND TELESCOPE INOPERATIVE OR ERRATIC

CAUSE	REMEDY
Pump disconnect not engaged	**Engage pump disconnect.**
Main relief valve malfunctioning	**See section on "Relief Valves".**
Low oil level	**Add oil as required.**
Rotary manifold leaking internally	**Reset rotary manifold.**
Tandem pump faulty	**See section on "Pumps".**

BOOM TELESCOPE CIRCUIT

TELESCOPE FUNCTION ONLY - WILL NOT OPERATE

CAUSE	REMEDY
Load too great	**Tilt boom pedal only halfway forward, not all the way forward ("high speed") . Reduce load or set boom length before lifting load.**
Both port relief valves sticking	**See section on "Relief Valves".**
Hose plugged or liner collapsed	**Replace hose.**

BOOM EXTENSION JERKY OR ERRATIC

CAUSE	REMEDY
Inadequate grease on boom pad surfaces	**Lubricate boom where pads contact boom.**
Wear pads damaged	**Replace wear pads.**
Wear pads shimmed to boom too tight	**Reshim wear pads.**
Faulty counter balance valve	**Replace counter balance valve.**
Loose chain system	**Adjust chains as required.**

TELESCOPE CYLINDER EXTENDS BUT WILL NOT RETRACT

CAUSE	REMEDY
Port relief valve sticking	**See section on “Relief Valves”.**
Hold valve malfunctioning	**Repair or replace.**
Internal leakage in cylinder	**See section on “Cylinder Leakage”.**
Extend valve malfunctioning	**Repair or replace.**

BOOM SECTIONS RETRACT UNDER LOAD

CAUSE	REMEDY
“O” ring around hold valve damaged	**Replace “O” rings.**
Hold valve not seating properly	**Repair or replace.**
Telescope cylinder by-passing	**See section on “Cylinder Leakage”.**

WINCH CIRCUIT

WINCH WILL NOT DEVELOP MAXIMUM LINE PULL

CAUSE	REMEDY
Main relief valve is set too low	**Readjust the main relief.**
Main relief valve is sticking	**See section on “Relief Valves”.**
Winch motor worn excessively or damaged	**See section on “Fluid Motor”.**
Tandem pump worn excessively or damaged	**See section on “Pumps”.**
Rotary manifold leaking internally	**Reseal rotary manifold.**
Low oil level	**Add oil as required.**

WINCH WILL LOWER BUT WILL NOT RAISE

CAUSE	REMEDY
The sprag clutch is assembled backwards	**Be certain that the winch is assembled properly.**
Insufficient parts of line for the load being lifted	**See the reeving diagram on the capacity chart.**

WINCH WILL RAISE BUT WILL NOT LOWER

CAUSE	REMEDY
The winch hold valve is mounted on the winch motor incorrectly	**Be certain that the winch is assembled properly.**
The winch hold valve spool is sticking	**Repair or replace.**
The winch brake is not releasing	**Be certain that the brake release line is open. If necessary, disassemble and inspect the brake components.**
Winch brake piston “O” ring damaged	**Replace “O” ring.**

WINCH WILL NOT HOLD LOAD (LOAD DRIFTS DOWN)

CAUSE	REMEDY
System back pressure too high	**Warm oil: check for restriction in down stream flow.**
The over-running sprag on the brake is broken	**Inspect and replace, if necessary.**
The automatic brake is not applying	**Be certain that the winch brake release line is not plugged and no foreign objects are in the brake assembly.**
The winch brake friction plates are worn	**Replace friction plates.**

WINCH CHATTERS WHEN LOWERING

CAUSE	REMEDY
The winch hold valve is set wrong or is malfunctioning	**Check the hold valve setting. If the winch continues to chatter, the holding valve is sticking. Inspect it for worn or damaged seals or contamination.**

OUTRIGGER CIRCUIT

ALL OUTRIGGERS INOPERATIVE

CAUSE	REMEDY
Electrical malfunction	**See section on “Electrical Controls”.**
Outrigger relief valve malfunctioning	**See section on “Relief Valves”.**
Outrigger diverter valve malfunctioning	**Repair or replace.**
Line to or from steer pump plugged or liner collapsed	**Clear blockage or replace hose.**
Low oil level	**Add oil as required.**
Steer pump worn or damaged	**See section on “Pumps”.**

INDIVIDUAL OUTRIGGER INOPERATIVE

CAUSE	REMEDY
Electrical malfunction	**See section on “Electrical Controls”.**
Cylinder leaking internally	**See section on “Cylinders”.**
Hold valve on jack cylinder not operating	**Repair or replace.**
Line plugged or collapsed between outrigger valve and cylinder	**Replace hose.**
Beam wedged in extended position	**Extend jack far enough to pick up end of beam and retract. Replace slider pad block on top of outrigger box to pick up end of beams.**

OUTRIGGERS WILL NOT LIFT MACHINE

CAUSE	REMEDY
Outrigger relief valve malfunctioning	**See section on “Relief Valves”.**
Outrigger diverter valve malfunctioning	**Repair or replace.**
Outrigger pump worn or damaged	**See section on “Pumps”.**
Cylinder by-passing	**See section on “Cylinders”.**

JACK CYLINDER DRIFTS DOWN

CAUSE	REMEDY
Hold valve on top of cylinder malfunctioning	**Replace cartridge.**
Thermal relief cartridge mounted in wrong end	**Check for proper assembly.**
Cylinder by-passing	**See section on “Cylinders”.**

PUMPS

FAILURE OF PUMP TO DELIVER FLUID

CAUSE	REMEDY
Pumps not engaged	**Engage pumps.**
Low fluid level in reservoir	**Add recommended oil and check level.**
Oil intake suction filter plugged	**Clean filter.**
Air leak in suction line, preventing priming or causing noise and irregular action of control circuit	**Repair leaks.**
Oil viscosity too heavy to pick up prime	**Use lighter viscosity oil. Follow recommendation for temperatures encountered.**
Broken pump shaft or parts broken inside pump	**Contact your local distributor; if necessary, refer to the manufacturer's manual for the correct instructions in pump disassembly and repair.**

NO PRESSURE IN SYSTEM

CAUSE	REMEDY
Pumps not engaged	**Engage pumps.**
Pump not delivering oil for any of the reasons listed previously	**Follow remedies given previously.**
Relief valve not functioning due to:	
Valve setting not high enough	**Increase pressure setting of valves.**
Valve leaking	**Check seat for score marks and reseat.**
Spring in relief valve broken	**Replace spring and readjust valve.**
Internal leakage in control valves or cylinders	**To determine location, progressively block off various parts of circuit. When trouble is located, repair. (Do not block between pump and relief valve).**

NO PRESSURE IN SYSTEM (CONTINUED)

CAUSE	REMEDY
Relief valve not functioning due to:	
Cold fluid	**Warm up system. Work with oil at recommended operating temperature range. (See Operation section).**
Air leak or restriction at inlet line	**Repair or clean.**
Internal parts of pump are worn excessively	**Replace pump.**

PUMP MAKING NOISE

CAUSE	REMEDY
Pump disconnect notengaged	**Shut engine off and engage pump disconnect.**
Partially clogged intake line, intake filter or restricted intake pipe	**Clean out intake filter screen or eliminate restriction. Be sure suction line is completely open.**
Air leaks:	
At pump intake pipe joints	**Test by pouring oil on joints while listening for change in sound of operation. Tighten as required.**
Air drawn in through inlet opening	**Check and add oil to reservoir if necessary.**
Air bubbles in oil	**Use hydraulic oil containing a foam depressant.**
Too high oil viscosity	**Work only with oil at recommended operation temperature.**
Oil intake suction filter plugged	**Clean filter.**
Rag, paper, etc., pulled into suction line or pump	**Remove.**
Worn or broken parts	**Replace.**

EXTERNAL OIL LEAKAGE AROUND PUMP

CAUSE	REMEDY
Shaft seal worn causing oil to leak into gear drive housing	**Replace.**
Loose fitting on pump intake or discharge	**Keep all joints tight.**
Damaged “O” ring seals between pump sections	**Replace.**
Damaged “O” rings at fittings	**Replace.**

EXCESSIVE WEAR

CAUSE	REMEDY
Abrasive matter in the hydraulic oil being circulated through the pump	**Clean suction filter and replace return filter. Drain & flush system as necessary.**
Viscosity of oil too low at working conditions1	**Check oil recommendation.**
Sustained high pressure above maximum pump rating	**Check relief valve setting.**
Air recirculation causing chatter in system	**Check for air being drawn into system. Use hydraulic oil with a foam depressant.**

BREAKAGE OF PARTS INSIDE PUMP HOUSING

CAUSE	REMEDY
Excessive pressure above maximum pump rating	**Check relief valve setting.**
Seizure due to lack of oil	**Check reservoir level, oil filter and possibility of restriction in suction line more often.**
Solid matter being wedged in pump	**Check suction line filter, drain and flush system as necessary.**

CONTROL VALVES

STICKING PLUNGERS

CAUSE	REMEDY
Excessively high oil temperature	**See section on "Excessive Heating of Oil in System".**
Dirt in oil	**Change oil. Clean system.**
Fittings too tight	**Check torque.**
Valve warped from mounting	**Loosen valve mounting bolts and check.**
Excessively high flow in valve	**Check to see if hoses from pump are not crossed or reversed.**
Plunger damaged	**Replace valve.**
Return spring damaged	**Replace faulty parts.**
Spring or detent cap binding	**Loosen cap, re-center and re-tighten.**
Valve not at thermal equilibrium	**Let system warm up.**

LEAKING SEALS

CAUSE	REMEDY
Paint on or under seal	**Remove and clean.**
Excessive back pressure	**Open or enlarge line to reservoir.**
Dirt under seal	**Remove and clean.**
Scored plunger	**Replace valve.**
Loose seal plates	**Clean and tighten.**
Cut or scored seal	**Replace faulty parts.**

LOAD DROPS WHEN CONTROL MOVED FROM NEUTRAL

CAUSE	REMEDY
Dirt in check valve	**Disassemble and clean.**
Scored check valve poppet or seat	**Replace poppet or lap poppet to seat.**

POOR HYDRAULIC SYSTEM PERFORMANCE OR FAILURE

CAUSE	REMEDY
Dirt in relief valve	**Disassemble and clean.**
Relief valve defective	**See section on "Relief Valves".**
Load too heavy	**Check line pressure.**
Internal valve crack	**Replace valve.**
Plunger not at full stroke	**Check movement of spool.**

RELIEF VALVES

CAN'T GET PRESSURE

CAUSE	REMEDY
Poppet stuck open or dirt under seal	**Check for foreign matter between poppets and their mating members. Members must slide freely.**

ERRATIC PRESSURE

CAUSE	REMEDY
Poppet seal damaged	**Replace damaged parts. Clean dirt and remove surface marks for free movement.**

PRESSURE SETTING NOT CORRECT

CAUSE	REMEDY
Wear due to dirt. Lock nut adj. screw loose	**See section on "Valve Adjustments".**

LEAK

CAUSE	REMEDY
Damaged seats, worn "O" rings, parts sticking due to dirt	**Replace worn or damaged parts. Inspect for free movement of components. Check seats for scratches, nicks, or other marks.**

FLUID MOTOR

MOTOR WILL NOT TURN

Pumps not engaged	**Engage pumps.**
No oil	**Fill reservoir to proper oil level.**
Pump broken	**Replace pump.**
Relief valve stuck open or set too low	**Clean and free relief valve spool and adjust to proper setting.**
Work load jammed or stuck	**Remove obstruction from work load.**
Large contaminating foreign bodies in fluid	**Flush hydraulic system completely. Use new oil and install new filters.**

SLOW OPERATION

CAUSE	REMEDY
Wrong oil viscosity	**Use proper viscosity oil.**
Rotary manifold leaking	**Reseal rotary manifold.**
Worn pump	**Repair or replace pump.**
Extremely high fluid temperatures causing pump and motor to slip (temperature increases as pump and motor wear)	**Add heat exchangers.**
Relief setting too low	**Set relief valve for proper psi.**

MOTOR TURNS IN WRONG DIRECTION

CAUSE	REMEDY
Hose connections wrong	**Reverse connections.**
Wrong timing	**Re-time motor.**

ERRATIC MOTOR OPERATION

CAUSE	REMEDY
Relief valve pressure set too low	**Adjust relief valve setting.**
Low oil level in reservoir permitting air to enter system	**Fill reservoir to proper level.**
Air being “sucked in” on inlet side of pump	**Tighten fitting(s) on pump inlet side.**

LEAK AT SHAFT

CAUSE	REMEDY
Worn or cut shaft seal	**Replace shaft seal.**

LEAK BETWEEN HOUSING AND WEAR PLATE OR BETWEEN WEAR PLATE AND GEROLER ASSEMBLY

CAUSE	REMEDY
Motor housing bolts loose	**Clean mating surfaces and tighten nuts to appropriate value.**
Pinched “O” ring seal	**Replace.**

LEAK AT OIL PORTS

CAUSE	REMEDY
Damaged seal or “O” ring	**Replace “O” ring or seal.**

LEAK AT OIL PORTS (CONTINUED)

CAUSE	REMEDY
Poor fittings	**Replace fittings carefully.**
Damaged threads	**Replace housing.**

CYLINDERS

CYLINDER STICKING OR BINDING

CAUSE	REMEDY
Damaged parts	**Repair or replace.**
Dirt or contamination	**Check oil condition. Check filters. Clean or replace filter elements. Change oil if condition requires it.**
Loose parts	**Tighten cylinder rod eyes, if loose. Check cylinder heads and tighten, if loose.**
Misalignment	**Check mounting pins and bushings. Tighten rod eyes.**

ERRATIC ACTION OF CYLINDERS

CAUSE	REMEDY
Air in system:	
Oil level is too low	**Add or change.**
Air leak	**Locate and correct.**
Foaming in reservoir	**Use hydraulic oil containing a foam depressant.**
Internal leakage	**See "Cylinder Leakage" next page.**
Main Relief pressure too low or valve sticking	**See section on "Relief Valve".**

CYLINDER LEAKAGE

Hydraulic cylinders may retract due to the cooling of the oil in cylinder. Oil shrinks approximately 4% per 100°F of cooling, or as an example, if a cylinder is extended 100” and it cools 100°F, it would shorten approximately 4”.

TELESCOPE CYLINDER

If excessive leak-down is encountered, check items in the following sequence:

1 With boom offside and horizontal, extend the boom approximately 6 ft. per section. Mark the first telescoping section at the end of the base section.

2 Elevate the boom to maximum angle and suspend a load on the hook. (7 tons on a 2-part line would approximate manufacturer’s inspection procedures.)

3 With engine shut off, hold or tie the telescope function lever in the full “extend” position for approximately 15 minutes.

4 Return the telescope lever to neutral, start engine, ground the load, and return the boom to horizontal. Re-mark the boom section as in (1). Measure the distance between marks to determine leak-down of the cylinder.

The manufacturer’s allowable drift specification for production machines is as follows:

With 14,300 lb. hook load, 2-part hoist line, boom extended about 6 ft. per section at maximum boom angle, and 160 degree F. hydraulic oil temperature, the leak-down per cylinder is not to exceed 3/4 inch in a 15-minute period.

IDENTIFY A DEFECTIVE HOLD VALVE in the cylinder which drifts excessively by interchanging the hold valve cartridge with one removed from a cylinder that is not drifting, or by replacement with a new cartridge. Before installing the cartridge, visually inspect the external “O” rings and backup washers. Retest per the procedure above to determine if hold was defective.

An alternate method to test hold valve would be to elevate boom and then disconnect the two hoses coming from valve bank. If oil continues to flow slowly from line to extend then it is a hold problem. If oil continues to flow from retract, then it is faulty or leaking by piston in cylinder.

IF THE HOLD VALVE IS NOT FOUND DEFECTIVE, the cylinder must be removed from the boom assembly for repacking and checking. Prior to reassembly of the cylinder, conduct an air test on the piston rod by blocking the retract ports on the rod near the piston end. Slip a plastic bag over piston end of rod and retain and seal with rubber band. Apply and hold a slight amount of air pressure at the retract port of the rod. (Port stamped with “R”.) Expansion of the plastic bag indicates a defective rod weldment or seals on the port tube in the rod.

WHEN REASSEMBLING THE CYLINDER, care should be taken to keep the piston rod assembly parallel in all planes with the cylinder barrel as the piston enters and is pushed down the barrel prior to gland engagement.

NOTE: An external leak from telescope cylinders or hydraulic line within the boom assembly does not cause leak-down without also having one or more of the above conditions present.

BOOM LIFT CYLINDER

The suggested procedure for identifying the specific cause of leak-down should be performed in the following sequence:

ELEVATE THE BOOM TO NEAR MAXIMUM ANGLE, not completely extended, with a boom length sufficient to winch up a convenient payload approximately one (1) foot from ground level. Shut of engine.

BOOM LIFT CYLINDER (CONTINUED)

DISCONNECT THE EXTEND HOSE, PILOT DRAIN HOSE, AND THE SMALL PILOT LINE HOSE at the holding valve ports and cap the pilot line hose and drain hose ends.

IF HYDRAULIC OIL CONTINUES TO RUN after the initial draining from either port of the hold valve as the hoist cylinder continues to leak-down, the cause is within the hold valve.

IF CYLINDER LEAK-DOWN OCCURS with no oil leak from the hold valve ports, the cause is within the cylinder.

OUTRIGGER JACK CYLINDER

The suggested procedure for identifying the specific cause of leak-down is similar to the boom lift cylinder procedure:

SET THE OUTRIGGERS.

ELEVATE THE BOOM TO NEAR MAXIMUM ANGLE, not completely extended, with a boom length sufficient to winch up a convenient payload approximately one (1) foot from ground level. Shut off engine and remove pressure from the hydraulic reservoir by loosening the filler cap.

DISCONNECT THE EXTEND HOSE FROM THE HOLD VALVE. This is a hose farthest away from the port tube and should have an “E” stamped next to it.

IF HYDRAULIC OIL CONTINUES TO RUN after the initial draining from the port of the hold valve as the jack cylinder continues to leak-down, the cause is within the hold valve.

IF CYLINDER LEAK-DOWN OCCURS with no oil leak from the hold valve port, the cause is within the cylinder.

DO NOT START THE ENGINE UNTIL THE HOSES HAVE BEEN RECONNECTED. The control valve spool is open-center to reservoir in the neutral position and return line oil would be pumped out.

EXCESSIVE HEATING OF OIL IN SYSTEM

HEATING CAUSED BY POWER UNIT (RESERVOIR, PUMP, RELIEF VALVE, AND COOLERS)

CAUSE	REMEDY
Relief valve set at a higher or lower pressure than specified. Excess oil dissipated through increased slippage in various parts, or through relief valve	**Reset relief valve to recommended pressure.**
Internal oil leakage due to wear	**Repair or replace faulty component.**
Viscosity of oil too high or too low	**Follow recommendations for correct viscosity grade to be used.**
Pumps assembled after overhaul may be assembled too tightly. This reduces clearances and increases rubbing friction	**Follow instructions when reassembling.**

HEATING CAUSED BY POWER UNIT (RESERVOIR, PUMP, RELIEF VALVE AND COOLERS) (CONTINUED)

CAUSE	REMEDY
Leaking relief valves	**Repair.**
Improper functioning of oil cooler	**Inspect cooler and see that it is working properly.**
Improper machine operation	**Return control to neutral when stalled, cylinder at end of stroke, etc.**

HEATING BECAUSE OF CONDITIONS IN SYSTEM

CAUSE	REMEDY
Restricted lines	**If lines are crimped, replace; if partially plugged for any reason, remove obstruction.**
Internal leaks	**Locate leaks and correct.**
Low oil level	**Check oil level and fill if necessary.**

ELECTRICAL CONTROLS

CAUSE	REMEDY
Rocker switch sticking	**Remove switch, check if hole is too tight. Cut out decal or file hole larger.**
Tripped circuit breakers	**Reset breaker**
Disconnected or broken wires	**Replace or repair.**
Open circuit	**Check with test light. Repair or replace.**
Low voltage	**Check wires and grounds.**
Poor engine solenoid connection	**Clean and tighten.**
Defective solenoid	**Replace.**
Solenoid failure	**Replace.**
Poor ground connections	**Clean and tighten connections.**

PROPANE HEATER

HEATER FAILS TO START (MOTOR DOES NOT RUN)

CAUSE	REMEDY
Fuse defective or burnt out	**Check fuse; replace if necessary.**
Electrical connection(s) defective	**Check all electrical connections, including ground; repair any defects.**
Full voltage not available at heater	**Check for power at the heater: at least 11 VDC with heater turned on. Trace system to find any fault(s).**
Motor defective	**Check motor. Replace if necessary.**

MOTOR RUNS, BUT NO COMBUSTION

CAUSE	REMEDY
Fuel supply blocked	**Check fuel supply by loosening the fitting on the outside of the heater and checking for propane odor. If propane odor is present, pull off the igniter wire completely and remove the igniter. Try to start the heater and listen for the solenoid click. Check for the odor of propane in the burner. If propane odor is present at bulkhead fitting, but not the burner head, the solenoid valve is defective or contaminated with some foreign object. The solenoid valve can become contaminated when a liquid take-off bottle is used instead of the required vapor take-off bottle. If the fuel system is contaminated, the lines and solenoid must be cleaned with a degreasing solvent.**
Temperature control &/or microswitch defective or out of adjustment	**Check temperature control switch and microswitch and microswitch for adjustment. Adjust, repair, or replace as necessary. See Section 6, “Repairs and Adjustments”.**

MOTOR RUNS, BUT NO COMBUSTION (CONTINUED)

CAUSE	REMEDY
Ignition pack defective or inoperative	**Check for spark by holding an insulated-handle screwdriver with the shaft grounded and the tip approximately 1/8" away from the high tension lug of the ignition coil. There should be a continuous strong spark. If no spark is produced, check that there is voltage applied to the ignition pack. If input voltage is present and no spark or a weak spark is produced, replace or repair the ignition pack.**
Tilt switch defective, improperly mounted or not getting power	**Check tilt switch. The switch must be secure in its bracket and be in the vertical position with the electrical leads pointing down. Check leads on both sides of switch for power. Replace if defective.**
Igniter defective or inoperative	**Check the igniter. To check, shut off the fuel tank and depress the start switch until the lines are purged of fuel. Remove the burner head and check the gap between the igniter and the burner tube. It should be 1/16" to 1/8". With the burner head grounded, move the START-RUN-OFF switch to the START position and check the gap for spark. If no spark is produced, the igniter may be dirty or defective. Before removing the igniter from burner head, check inside the burner head to determine if any carbon threads or chips are present which could short the plug.**
Fuel not suitable for temperatures encountered	**Check with your propane supplier to be sure your fuel is suitable for the temperatures encountered. Around -10°F, propane may not produce enough pressure to pass through the regulator.**

HEATER REMAINS ON BURNER CYCLE AFTER HEAT DEMANDS ARE MET

CAUSE	REMEDY
Temperature control &/or microswitch defective or out of adjustment	**Check temperature control switch and microswitch and microswitch for adjustment. Adjust, repair, or replace as necessary.**
Bi-metal blade broken or linkage out of adjustment	**Check bi-metal blade and linkage and adjust, repair or replace as necessary.**
Dirt on fuel solenoid valve lip	**Clean solenoid valve lip.**

EXCESSIVE POPPING OR BACKFIRING

Ignition pack defective or inoperative	**Check for spark by holding an insulated-handle screw driver with the shaft grounded and the tip approximately 1/8" away from the high tension lug of the ignition coil. There should be a continuous strong spark. If no spark is produced, check that here is voltage applied to the ignition pack. If input voltage is present and no spark or a weak spark is produced, replace or repair the ignition pack.**
Full voltage not available at heater	**Using voltmeter, check to be sure full voltage is available for heater operation, at least 11 VDC with heater turned on. Trace system to find fault.**
Solenoid defective	**Check solenoid. When the START-RUN-OFF switch is in the RUN position, the solenoid should produce an audible click and remain open until heater cycles off.**
In extremely cold weather, the regulator may become frosted. As it thaws and freezes, the heater will burn intermittently	**No action recommended.**
Clogged or restricted exhaust	**Check exhaust for blockage or restrictions. Clean and clear as necessary.**

EXCESSIVE SMOKING AT EXHAUST PORT AND BUILDUP OF CARBON IN HEAT EXCHANGER

CAUSE	REMEDY
Air inlet tube blocked	**Check for plugged or blocked air inlet tube and clear if necessary.**
Low voltage	**Check for low voltage, at least 11 VDC.**
Defective pressure regulator	**Check for defective pressure regulator. There should be 11 inches water pressure in the propane supply line at the connector.**

HEATER DOESN'T SWITCH OFF AFTER PURGE (COOL DOWN) CYCLE

CAUSE	REMEDY
Flame switch will not open	**Replace.**

MAINTENANCE FREE BATTERY TESTING

VISUAL INSPECTION

CAUSE	REMEDY
Visible damage, terminal leakage, etc.	**Cannot be used. Replace.**

ELECTROLYTE LEVELS & STATE OF CHARGE

NOTE: PROCEED DIRECTLY TO CAUSE THAT APPLIES

CAUSE	REMEDY
Level at top of plates. Water cannot be added	**Replace.**
If there is an indicator and it shows low level	**Replace.**

ELECTROLYTE LEVELS & STATE OF CHARGE (CONTINUED)

NOTE: PROCEED DIRECTLY TO CAUSE THAT APPLIES

CAUSE	REMEDY
Level OK, unknown, or water can be added. Stabilized voltage below 12.4 volts*	**Add water if needed (if possible). Charge, then turn on high-beam head lamps (or 15 amp load for 15 seconds). Proceed to load test.**
If there is an indicator and it shows low charge	**Charge, then turn on high-beam head lamps (or 15 amp load for 15 seconds). Proceed to load test.**
Stabilized voltage above 12.4 volts* or indicator indicates charged	**Perform load test.**

LOAD TEST

CAUSE	REMEDY
Perform load test using the following procedure: 1. Connect voltmeter and ampere load equal to 1/2 cold cranking amperes @ 0°F (-18°C) rating of battery for 15 seconds. 2. Observe voltage at 15 seconds with load on. 3. Refer to voltage chart	**If the voltage remains below the voltage chart levels, replace battery. If the voltage is equal to or above chart values, return to service.**

VOLTAGE CHART

ESTIMATED ELECTROLYTE TEMPERATURE		MINIMUM REQUIRED VOLTAGE UNDER 15 SECOND LOAD
70° F	(21° C) & ABOVE	9.6
60° F	(16° C)	9.5
50° F	(10° C)	9.4
40° F	(4° C)	9.3
30° F	(-1° C)	9.1
20° F	(-7° C)	8.9
10° F	(-12° C)	8.7
0° F	(-18° C)	8.5

*** IF WATER CAN BE ADDED TO A BATTERY, A HYDROMETER READING OF 1.225 @ 80° F (27° C) CAN BE USED INSTEAD OF THE 12.4 VOLTAGE READING.**

ANTI-TWO BLOCK SYSTEM

PANEL LIGHT & HORN WILL NOT COME ON WITH BOOM SWITCH WEIGHT LIFTED

CAUSE	REMEDY
Burned out fuse	**Check and replace fuse (8 amp only).**
Broken wire	**Check voltage in control panel between terminals #0 and #37. If 0 volts, check between ignition post of ignition switch and ground. If 12 volts available, wire to control panel is bad. Correct.**

HORN WORKS, BUT NO LIGHT WITH SWITCH WEIGHT LIFTED

CAUSE	REMEDY
Light bulb burned out	**Replace bulb.**

LIGHT AND HORN ARE ON WITH HOOK BLOCK NOT CONTACTING SWITCH WEIGHT

CAUSE	REMEDY
Jumper wire or jib/rooster sheave not plugged in boom head	**Plug in.**
Boom head weight wire rope broken or hung up	**Check that weight is attached to wire and hanging freely. If rope is caught up on something, correct.**
Jib or auxiliary boom head switch plugged in, but no weight	**Attach weight.**
Broken electrical cable or bad connection	**Check all cable for visible damage, then remove wire from terminals #3 and #6 in control panel and check for continuity. If circuit is open, check the wires inside cable reel, and wires from the reel to the boom head switch. If the wires are OK, check the anti-two block switch. If there is continuity between #3 and #6 check the relay in the panel.**

LIGHT AND HORN ARE ON WITH HOOK BLOCK NOT CONTACTING SWITCH WEIGHT (CONTINUED)

CAUSE	REMEDY
Defective two block switch	**Check for correct mechanical operation. If OK, remove cover and wires from terminals #1 and #2. With arm pulled down, there should be a closed circuit between them. With the arm up, the circuit should be open. If all conditions are not met, replace switch.**
Defective relay in panel	**Check for 12 volts between relay pins #30 (hot) and #86 (ground). If voltage is 0, check for voltage between pin #87a and ground. If 12 volt, replace relay (With no electrical power to the relay, pins #30 and #87a should show continuity. With 12 volts to either #85 or #86 and the other grounded, there should be continuity between pins #87 and #30.)**

INDEX

SECTION 6

SUBJECT **PAGE**

As the operator, it is your responsibility to detect any unusual, sounds, odors, or other signs of abnormal performance that could indicate trouble ahead.

By detecting any problems in their early stages, you can save yourself unnecessary downtime and your employer a lot of money! Therefore, it is also your responsibility to use good judgment in detecting failures in quickly and repairing them. If you don't, one failure can lead to another.

Before attempting to make an adjustment yourself, ask yourself if you have the RIGHT TOOLS, IF you have the PROPER TEST EQUIPMENT and IF you can accurately DIAGNOSE the cause of the problem.

If you can't answer YES to all three questions, rely on your Distributor Serviceman. He has the right tools, testing equipment and service knowledge to pin-point the problem in minutes instead of the hours consumed in hit-or-miss methods. TIME IS MONEY! He will save it for you.

If you decide to attempt an adjustment yourself, follow a logical TROUBLE SHOOTING PROCEDURE. Don't simply replace parts until the trouble is found.

VALVE ADJUSTMENTS

Setting hydraulic pressure is a complex operation and should be performed only after satisfying the following conditions.

1. Warm the hydraulic oil to 130° F in normal conditions. *NOTE: If the normal hydraulic operating temperature is substantially above or below 130° F use that value instead.*

2. Be sure the correct engine speed is used as the relief valve setting will vary with the flow rate.

3. Be certain to calibrate the pressure gauge used. Gauge calibration can be lost if the gauge is subjected to pulsating pressure for a few seconds. The gauge must have a proper snubber to read center of pump pressure ripple or erroneous readings will result.

MAINTENANCE CHECKS All the relief valve maintenance checks are conducted an a SEMI-ANNUAL BASIS. Check the relief valves and make the necessary adjustments by the following procedures.

The relief valves used on this hydraulic crane have a screw type adjustment. If it is determined that the valve is out of adjustment, follow this general adjustment procedure.

NOTE: Some machines are equipped with auxiliary winch plumbing even though an auxiliary winch is not installed. on these machines you must follow the procedure for setting the auxiliary winch relief valve.

VALVE ADJUSTMENTS

⚠ CAUTION

THIS MACHINE USES A PRESSURIZED HYDRAULIC RESERVOIR. THE PRESSURE MUST BE RELEASED BEFORE ANY HYDRAULIC LINE OR CONNECTION IS OPENED.

Failure to do so will result in substantial loss of oil and may cause personal injury. The pressure is relieved by turning the reservoir cap counterclockwise to the first stop. **DO NOT** turn the cap beyond the first stop until all pressure has been released. This will cause the cap to be blown off the reservoir with sufficient force to cause personal injury. **DO NOT** place any portion of your body above the reservoir cap while relieving pressure or removing cap.

BOOM HOIST & MAIN RELIEFS Check the boom relief settings as follows:

1. Operate the boom over relief to warm the oil if necessary.
2. Attach a calibrated pressure gauge to test port on the inlet pressure port at the valve bank.
3. Lower the boom completely and continue to boom down with the engine running at full governed rpm. The relief setting should b 4500 psi. If necessary, adjust relief valve.

BOOM RELIEF ADJUSTMENTS Adjust the boom hoist, retract, and telescope reliefs using the following procedures.

Adjust the boom hoist relief by loosening jam lock nut on relief valve. Adjust valve with adjusting screw while booming up or down over relief withe engine at maximum governed rpm. Screw in to increase pressure setting; out to decrease it. Retighten lock nut when proper setting is obtained.

EXTEND/RETRACT RELIEFS The initial range has been preset. Adjustment is accomplished by loosening the jam nut and either turning the adjusting screw in to increase pressure or backing it off to lower pressure. Retighten the jam nut when the desired pressure is obtained.

Set extend/retract by the following procedure:

First, retract the boom completely and continue to retract over relief with the engine running at full governed rpm. Initially, set the retract port relief valve (located on spring cap end of telescope section) to obtain a reading of 3500 psi.

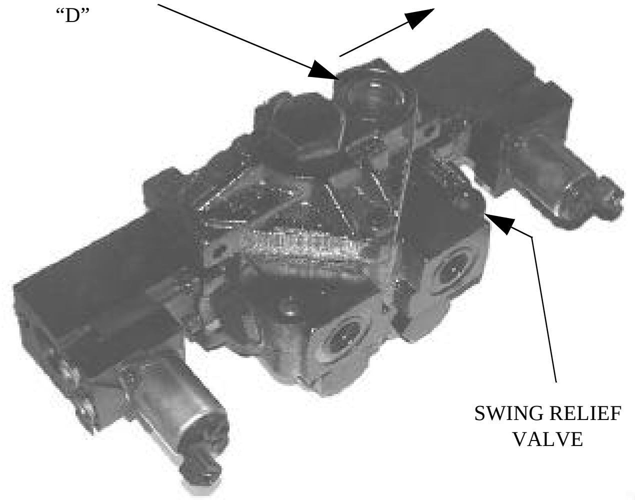
MAIN WINCH RELIEF Check the winch relief setting using the following procedure:

1. Attach a pressure gauge to the test port on the mid-section inlet port.
2. Disconnect and plug the brake line at the piston housing on the winch.
3. Restart the engine and run at high idle speed.
4. Winch and hold the lever in the “lower” position while obtaining a reading. The proper setting is 4500 psi at idle. The winch relief is located on the mid inlet section of the valve bank. It is adjusted in the same manner as the boom relief.

AUXILIARY WINCH RELIEF Check the pressure using the following procedure. The auxiliary winch pressure is controlled with a relief valve in the auxiliary winch valve.

1. Attach a pressure gauge to the main winch test port which is also used to check auxiliary winch pressure.
2. Disconnect and plug the brake line at the piston housing of the auxiliary winch.
3. Restart the engine and run at high idle speed.
4. Winch down and hold the lever in the “lower” position while obtaining a pressure reading. The proper setting is 4500 psi. If required, adjust the relief valve at the auxiliary winch valve. This relief is adjusted in the same manner at the boom relief.

VALVE ADJUSTMENTS



SWING RELIEF Check the swing relief using the following procedure:

NOTE: Prior to checking the swing relief valve pressure setting the outrigger relief MUST be set to the proper pressure.

1. Operate the boom over relief to warm the oil if necessary.

2. Attach a calibrated pressure gauge in test port "D" see illustration below.

NOTE: Test port "D" is located on the swing valve which is mounted inside the super structure just to the left of the swing reduction unit.

⚠ CAUTION

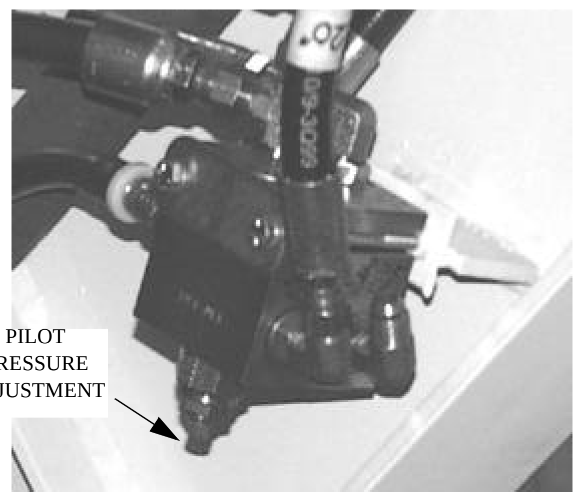
3. Set the swing brake and begin to attempt to swing the machine against the swing brake. You should exercise caution in doing this until you know that the swing brake is in good working order and will hold against the swing pressure.
   Once you have verified that the swing brake is holding the engine RPM should be brought up to full governed speed slowly. The swing pressure should be 2500 PSI ± 50 PSI. If necessary adjust the relief.

NOTE: If the swing pressure is low be certain to use cation when adjusting, if the swing brake is not in proper working order the increase in pressure may allow the machine to swing through the brake.

SWING RELIEF VALVE ADJUSTMENT Adjust this relief using the following procedure:

Remove the acorn nut and loosen the jam nut on the relief valve. Adjust the relief valve with the adjusting screw while attempting to swing against the swing brake at full engine RPM. Screw in the adjustment to increase the pressure and out to decrease it. When the pressure is at 2500 PSI ± 50 PSI tighten the jam nut.

Recheck the pressure after tightening the jam nut as the pressure may change due to tightening the jam nut.



PILOT CONTROL VALVE Check the pilot pressure using the following procedure:

Insert pressure gauge in front of winch valve. Use quick disconnect located on lower front pilot cap. With engine at idle and boom retract running over relief, depress boom retract pedal.

The pilot pressure should be 500psi ± 25psi. Turn screw 1/4 turn clockwise to increase pilot pressure. Turn screw 1/4 turn counter-clockwise to decrease pilot pressure. Recheck pressure at winch valve.

VALVE ADJUSTMENTS

RELIEF VALVE REPAIR RECOMMENDATIONS The cartridge type service port reliefs used in the swing valve are of the pilot poppet type with external adjustment. Any malfunctioning is usually the result of foreign matter lodging between the piston, relief valve poppet, and check valve.

To perform service, clean the surrounding area and remove the complete relief valve cartridge. Examine the seat in the main valve housing for grooves or ridges. If damaged, either replace the valve or have it re-machined.

The design of the pilot poppet and its seat provides positive seating and very seldom requires any maintenance. The pilot section can be removed from the cartridge housing without disturbing the setting.

With it will come the check valve poppet and other internal parts. These are easily disassembled and should be examined for foreign matter. All seats and seating surfaces should be free of nicks, scratches, or grooves. Examine “O” rings and back-up washers for any damage. If any parts are found to be faulty, replace the relief cartridge. All moving parts should slide freely, with only seal friction being present. After inspecting and cleaning, immerse all parts in hydraulic oil and re-assemble. If pressure setting was not disturbed, unit can be tested for proper functioning under normal working conditions. If operating difficulties indicate that the pilot poppet is still leaking or sticking, replace the relief.

OUTRIGGER RELIEF Use the 5000 psi test gauge and check as follows:

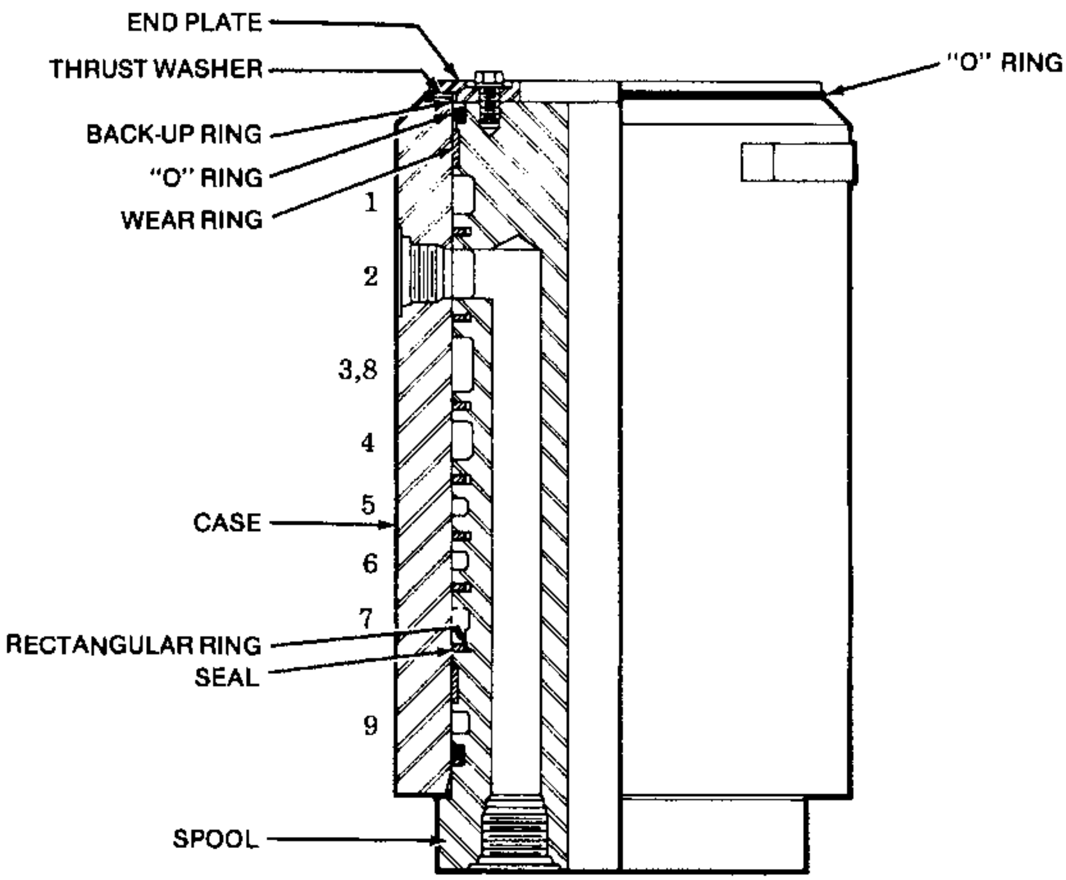
1. Attach the gauge at the quick disconnect on the diverter valve (B), located on the L.H. side of the front outrigger box.

2. Start engine and run at full throttle.

3. Set the outrigger extend/retract switch to the retract position and read the gauge. The correct pressure setting is 2500 psi outrigger relief. The relief valve is located above the outrigger diverter valve. Adjust to proper setting as follows:

OUTRIGGER RELIEF ADJUSTMENT With the test gauge still attached to the test port, remove the hex cap, insert an allen wrench. adjust to the proper setting while holding the outrigger in the retract position. Turn in to increase pressure, out to decrease. After completing adjustment, replace cap on the relief valve.

ROTARY MANIFOLD



Use the following procedures when disassembling, inspecting, repairing, and reassembling the rotary manifold.

⚠ CAUTION

AS SOON AS THE ROTARY MANIFOLD IS READY TO BE PLACED INTO OPERATION, IT SHOULD BE SLOWLY ROTATED SEVERAL MINUTES TO ALLOW ANY ENTRAPPED AIR TO ESCAPE AND TO FACILITATE REFORMING OF SEALS THAT MAY HAVE TEMPORARILY DEFORMED DURING STORAGE.

All overhaul should be done in a clean, enclosed facility with personnel familiar with hydraulic systems and cleanliness procedures.

DISASSEMBLY

The rotary manifold may be disassembled by removing the four capscrews and the top plate.

NOTE: Be sure to mark an index point on the case and spool to insure proper reassembly.

INSPECTION AND SEAL REPLACEMENT

1. The "case" bore should be thoroughly washed with solvent or diesel fuel and inspected for signs of "scoring" or deep scratches. This type of damage is generally caused by the presence of foreign material in the hydraulic system. No satisfactory method of repairing this type of damage can be conducted in the field.

ROTARY MANIFOLD

INSPECTION AND SEAL REPLACEMENT
(continued)

2. The “spool” should be carefully washed in solvent or diesel fuel. The seals and “O” rings should not be removed from the spool unless they show signs of wear or damage. *NOTE: If the seal is removed for any reason, it should be replaced since removal will almost always damage it beyond use.*

When installing a new seal and ring, it must be “walked” into place past other seals and oil grooves and then into its own groove in the same manner that the bead of a tire is “walked” into the wheel rim. The spool should be well oiled to aid in this assembly. Best results can be achieved if the spool, with the seals mounted on the end, is allowed to sit overnight. This gives the seals a chance to adjust to normal size.

REASSEMBLY

1. The top and bottom “O” rings and back-up washers can be replaced without removing the spool. Removing the top cover exposes the top “O” ring. The spool will drop out of the case, exposing the bottom “O” ring.

CAUTION

UPON REASSEMBLY, INSTALL THE UPPER “O” RING AND BACK ... IS IN THE CASE. THIS ... AGE WHICH MIGHT RESULT FROM SLIDING PAST PORT OPENINGS.

2. The rotary manifold should be reassembled using a generous coat of oil on the case ID and spool OD. Generally, reassembly is most successful by placing the case in a vertical position and inserting the spool into the case. Each seal and wear ring should be compressed by hand to initially enter the case bore. With the spool fully inserted into the case, the assembly may be “up-ended” to replace the end plate.
3. Ports should be properly protected, capped, and, preferably, oil filled without pressure.

NOTE: If the rotary manifold is oil filled and plugged, ample air space should be allowed for the expansion of oil due to temperature changes.

CAUTION

IT IS IMPORTANT THAT THE SPOOL FLOATS FREELY WITH THE CASE TO PREVENT WEAR AND LEAKAGE. THE SPOOL IS HELD STATIONARY WITH RESPECT TO THE LOWER BY A RESTRAINING BRACKET DE... E ECCENTRICITY. TH... OULD BE SHIMMED A... S NECESSARY TO INSURE CONCENTRIC ROTATION. ROTATE THE MACHINE WHILE VISUALLY CHECKING THE ALIGNMENT. THE BRACKET MUST NOT BIND DURING ROTATION.

STEERING PRIORITY VALVE

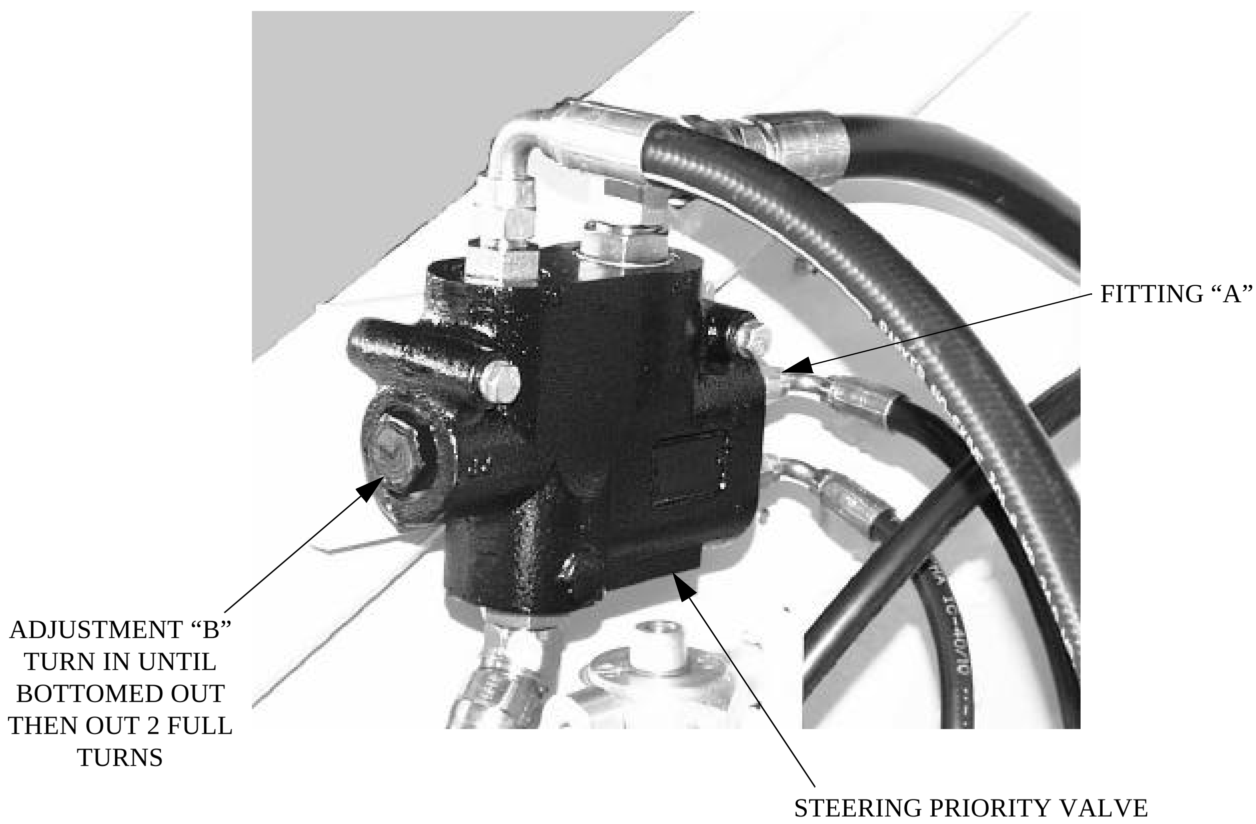
The steering priority valve is preset at the factory and will normally not require any additional adjustment. In the event that a new valve is installed or steering performance is poor and all other components and adjustments have been verified, adjustment of the valve may be required.

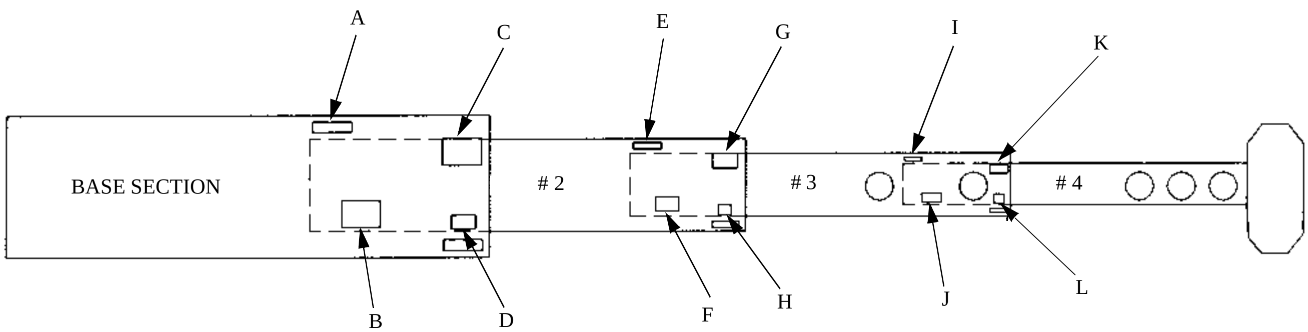
The steering priority valve is located inside the super structure just to the right of the rotary manifold.

STEERING PRIORITY VALVE ADJUSTMENT

Adjust this valve using the following procedure:

1. Remove the hydraulic hose connected to fitting “A”.
2. Remove fitting “A”.
3. Turn adjustment “B” clockwise until it bottoms out.
4. Turn adjustment “B” counterclockwise 2 full turns.
5. Reinstall Fitting “A” and the hydraulic hose.



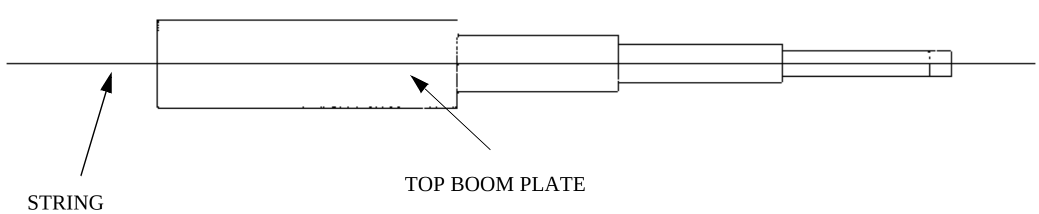


BOOM ADJUSTMENT

The 126 foot boom installed on this machine must be kept in proper alignment and adjusted as required. Boom lubrication intervals should also be used to inspect boom alignment. Should adjustment be necessary use the following procedure:

1. With the boom retracted and level, remove the top covers on the base section. If pads “C”, “G”, and “K” are installed remove the shims. If pads “B”, “F”, and “J” are installed, loosen the capscrews . The retaining bolts and eccentrics at pads “A”, “E”, and “I” are to be backed off to enable aligning the boom sections later.
2. With the boom still retracted adjust the cast iron blocks “D”, “H”, and “L” to center the boom sections at the front and allow approximately <u>1/16 to 1/8 inch</u> clearance on each side between the cast padr and the boom section.
3. Lubricate pads “A”, “C”, “E”, “G”, “I”, and “K” and extend the boom.
4. Visually align #2 boom section with base section by shimming pad “B” on either side to bring the #2 section into alignment. Check the alignment of the #2 section by running a string along the top of the base and #2 section as shown below. Shim and install the other pad “B” to a 1/32 inch clearance between the pad surface and the #2 boom section.

CHECKING FOR PROPER ALIGNMENT



5. Align the #3 boom section with the #2 boom section in the same manner as step 4 by shimming and installing pads "F".

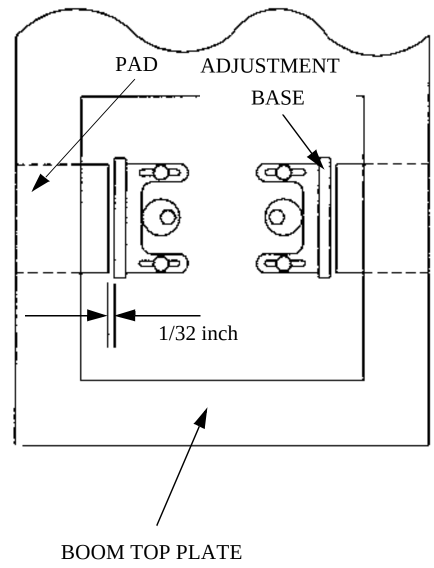
6. Align #4 (tip) boom section with the #3 boom section in the same manner as step 4 by shimming and installing pads "J".

7. Shim and tighten pads "C", "G", and "K" to 1/32 inch clearance between the pad surface and the boom section on each side with the boom extended.

8. Grease the boom **ahead** of the wear pads.

9. Retract the boom, checking that no excessive binding occurs.

10. Adjust the brackets on pads "A", "E", and "I" so the pads contact the base boom section. Then "back off" until there is 1/32 inch max clearance between the pad adjustment base and the pad. This must be done for the left and right pad for each section. This will maintain a total clearance of 1/16 inch. Tighten the lock bolts. This is done with the boom retracted.



11. A final check of boom alignment should be made by "stringing" as described earlier and also by a visual inspection with the boom fully extended and at maximum angle.

BOOM CHAIN ADJUSTMENT
- 4 SECTION BOOM -

BOOM CHAIN ADJUSTMENT: For proper operation and boom life the extend and retract chains must be adjusted properly. To adjust these chains use the following procedure.

THIRD SECTION EXTEND AND RETRACT CHAINS (4 SECTION BOOMS):

1. Fully retract the boom.

2. Measure the gap between the front of second section and the back of the third section. This gap should be .25 inch to .38 inch.

3. If adjustment is required, extend the boom approximately 1/2 way.

NOTE: Before attempting to turn one of the adjusting nuts, extend or retract the boom slightly to relieve the tension on that nut. After extending the boom, adjustment A will be under tension and B will be free. After retracting the boom, adjustment B will be under tension and A will be free.

4. If the gap is less than .25 inch, loosen adjustment B and tighten adjustment A until the gap is within specifications.

5. If the gap is more than .38 inch, loosen adjustment A and tighten adjustment B until the gap is within specifications.

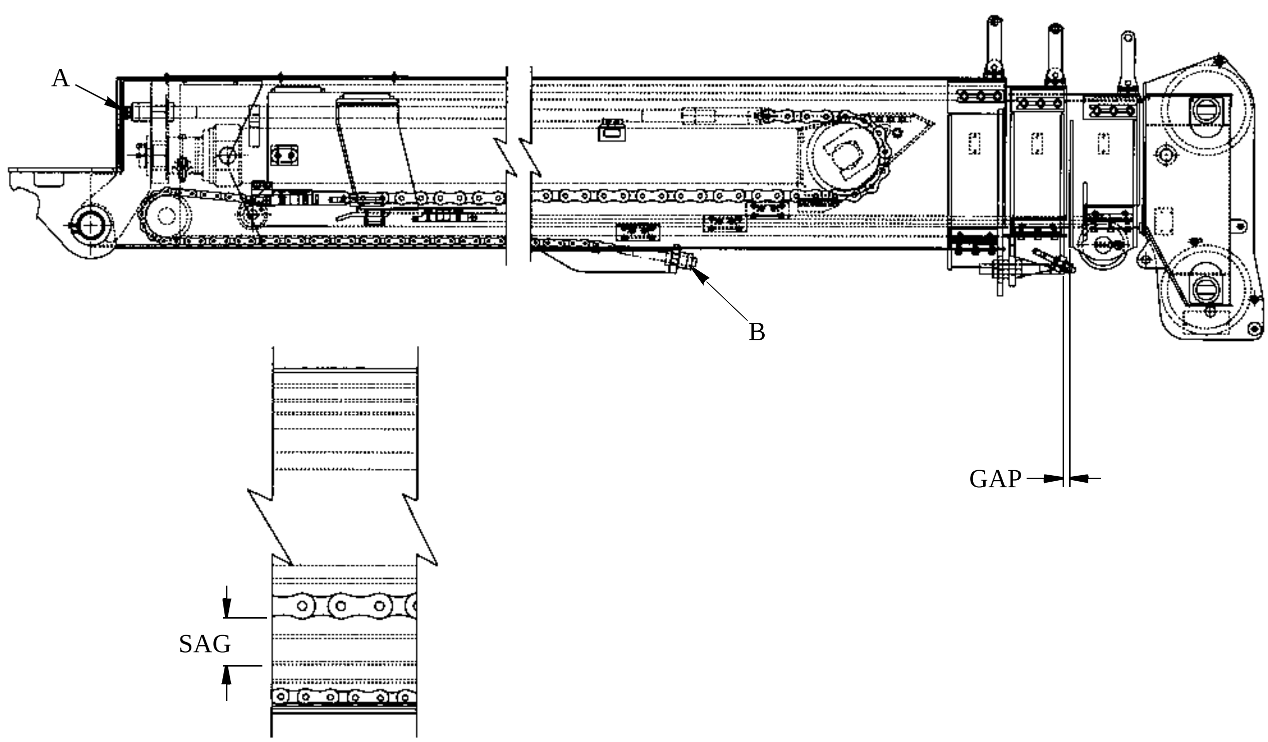
6. Fully retract the boom and recheck the gap. Repeat step 3 through 5 if necessary.

7. Fully extend the boom horizontal.

8. Through the first hole in the side plate of the second boom section (the hole closer to the base section), measure the sag of the retract chain. This measurement must be taken from the bottom of the second section to the bottom of the chain. This dimension should be 2.25 inches to 2.50 inches.

9. If the dimension is greater than 2.50 inches, loosen adjustments A and B equal amounts until the measurement is within specifications.

10. If the dimension is less than 2.25 inches, tighten adjustments A and B equal amounts until the measurement is within specifications.



BOOM CHAIN ADJUSTMENT
- 4 SECTION BOOM -

FOURTH SECTION EXTEND AND RETRACT CHAINS (4 SECTION BOOMS):

1. Fully retract the boom.

2. Measure the gap between the front of third section and the back of the tip section. This gap should be .25 inch to .38 inch.

3. If adjustment is required, extend the boom approximately 1/2 way.

NOTE: Before attempting to turn one of the adjusting nuts, extend or retract the boom slightly to relieve the tension on that nut. After extending the boom, adjustment C will be under tension and D will be free. After retracting the boom, adjustment D will be under tension and C will be free.

4. If the gap is less than .25 inch, loosen adjustment D and tighten adjustment C until the gap is within specifications.

5. If the gap is more than .38 inch, loosen adjustment C and tighten adjustment D until the gap is within specifications.

6. Fully retract the boom and recheck the gap. Repeat step 3 through 5 if necessary.

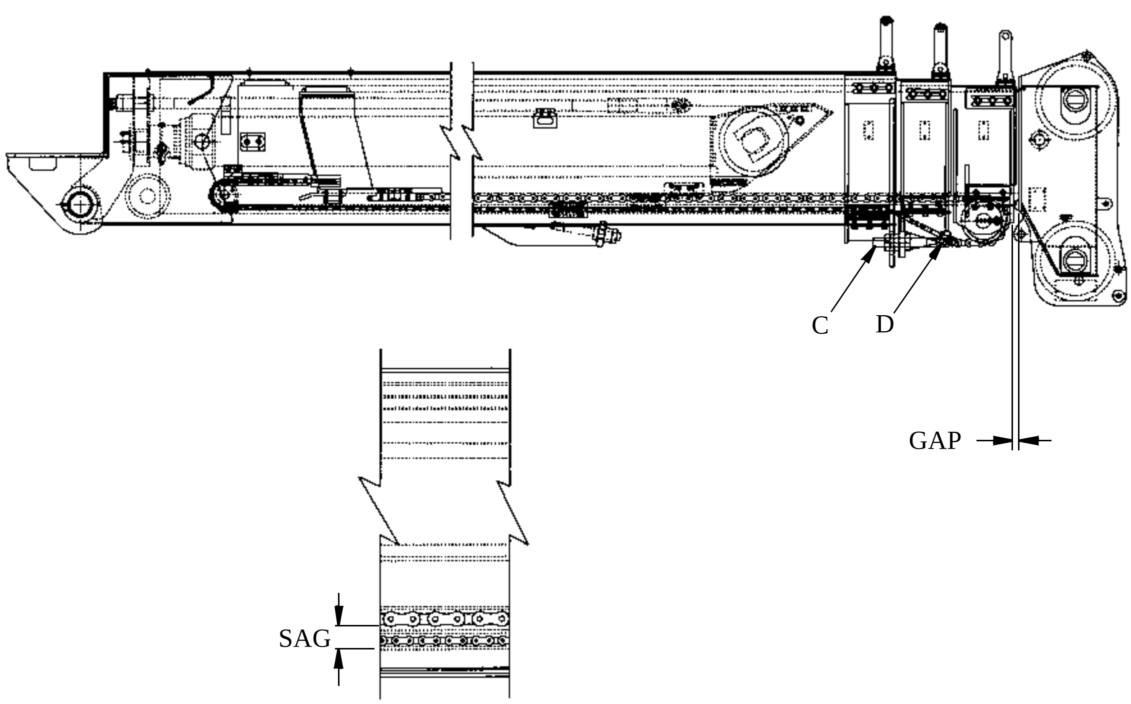
7. Fully extend the boom horizontal.

8. Through the first hole in the side plate of the third boom section (the hole closer to the second section), measure the sag of the retract chain. This measurement must be taken from the bottom of the third section to the bottom of the chain. This dimension should be 2.75 inches to 3.00 inches.

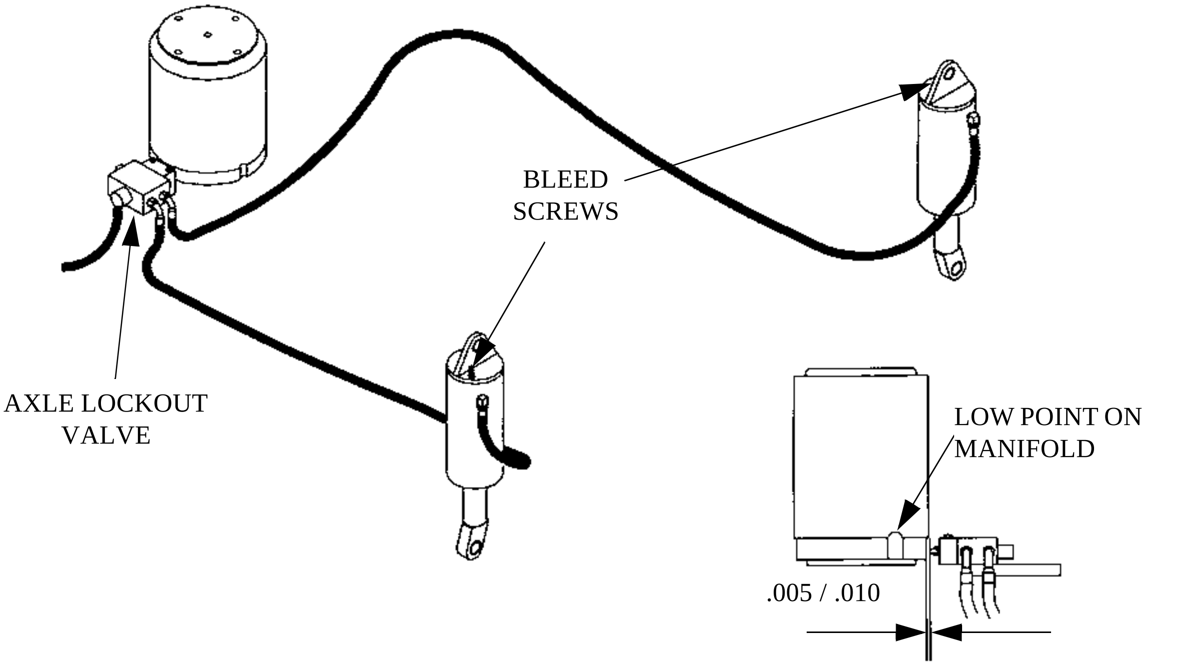
9. If the dimension is greater than 3.00 inches, loosen adjustments C and D equal amounts until the measurement is within specifications.

10. If the dimension is less than 2.75 inches, tighten adjustments C and D equal amounts until the measurement is within specifications.

11. Under the same condition, the maximum sag in the extend chain should be 7.00 inches to 7.50 inches. This measurement is from the bottom of the third boom section to the top of the extend chain.



AXLE LOCKOUT SYSTEM



AXLE LOCKOUT SYSTEM

> **CAUTION**
>
> **Air in the axle lock circuit decreases stability. Bleed the system immediately whenever this occurs.**

If the axle does not hold in the blocked position or oscillates when the upper structure is swung 20 degrees from the travel position, bleed the system.

Swing the retracted unloaded boom into the travel position so that the lock valve will open. With the engine running at an idle, loosen the bleeder screw. When a steady flow of oil is running from the bleed screw, retighten the bleeder screw.

ADJUSTMENT

With the cam plunger fully retracted, adjust valve position for .005-.010 inches gap between the cam roller and the cam travel area on the manifold. Do not measure at the low point on the manifold.

Tighten and secure with nuts, washers, and capscrews.

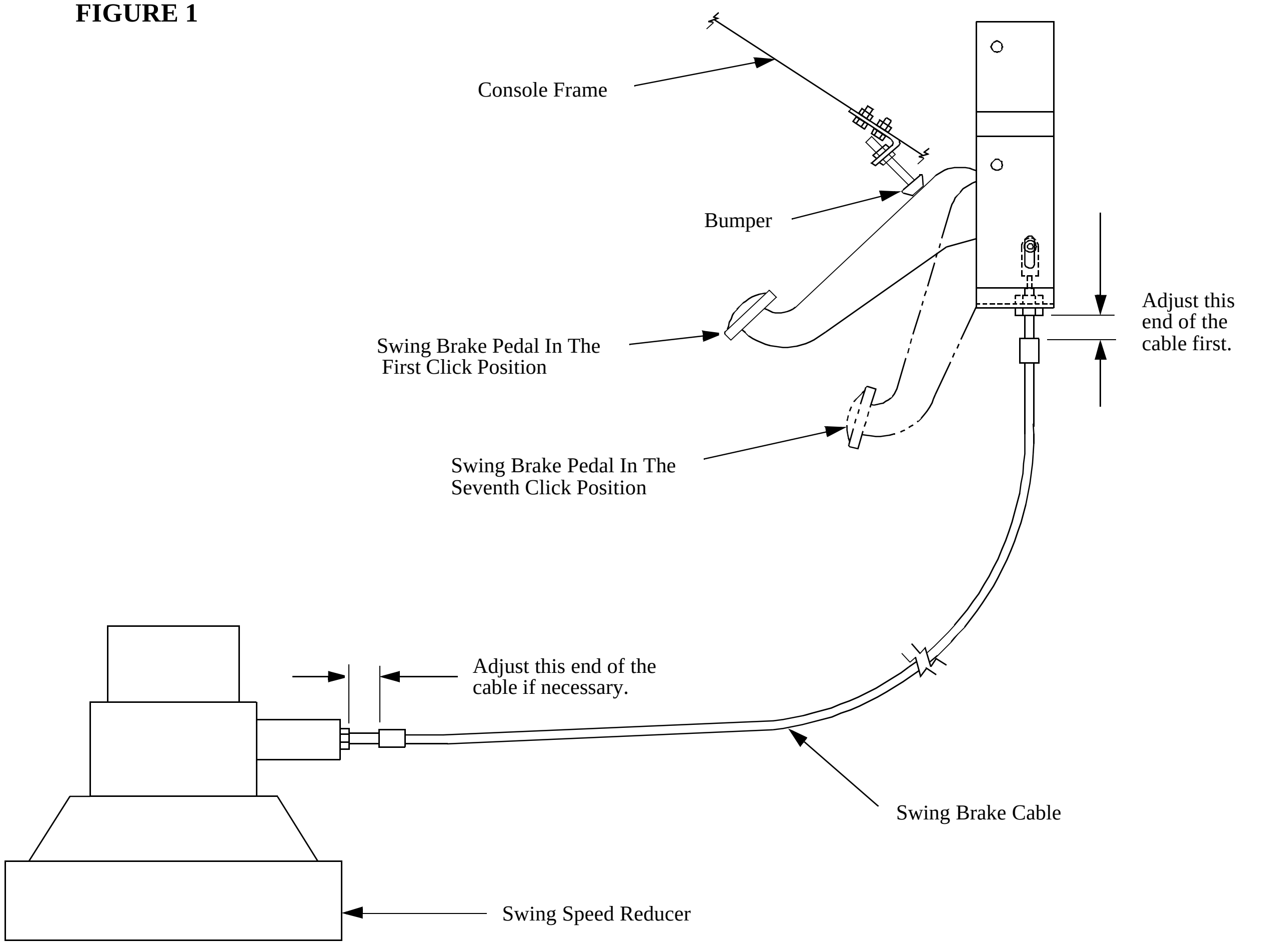
OPERATION CHECK

For safe operation of the crane when operating on rubber, the axle lockout valve should be checked daily as follows:

1. Place boom in travel position.
2. Drive one tire of the rear (oscillating) axle up on an eight inch block.
3. Swing the retracted unloaded boom approximately 20 degrees from the center position.
4. Drive the crane off the block. If the tire remains in the up position proceed with step (5). If the tire does not remain in the up position readjust or replace lockout valve.
5. Allow crane to set for three to five minutes.
6. Observe the tire, it should remain in the up position.
7. Swing the crane back to the center position, the tire should return to its original position. If not readjust or replace the lockout valve and repeat this procedure.

CONTROL LINKAGE ADJUSTMENTS

FIGURE 1



Swing Brake Control Adjustment:

(a) During normal operation, the swing brake pedal should be operating in the 4 to 5 click range if the swing brake pedal is properly adjusted. If the swing brake pedal is operating in the 6 or 7 click range during normal operation, the swing brake cable will need to be adjusted.

CLICK	DESCRIPTION
1	Bumper should rest against the pedal.
2	Brake disks should begin to engage.
3	
4	Brake discs should be fully engaged
5	and should hold at full engine RPM.
6	Swing brake cable should be adjusted
7	and/or brake pads may need replacing.

CAUTION

The cables used on this machine are sealed. Never adjust a cable to the point that the threads on the rod end are pulled into the seal.

Note: If the machine is ***not*** *equipped with a swing brake pedal bumper on the console frame, skip step "b".*

(b) Refer to figure 1. Release the swing brake and move the swing brake pedal to the first click position. Adjust the bumper to rest against the swing brake pedal.

CONTROL LINKAGE ADJUSTMENTS

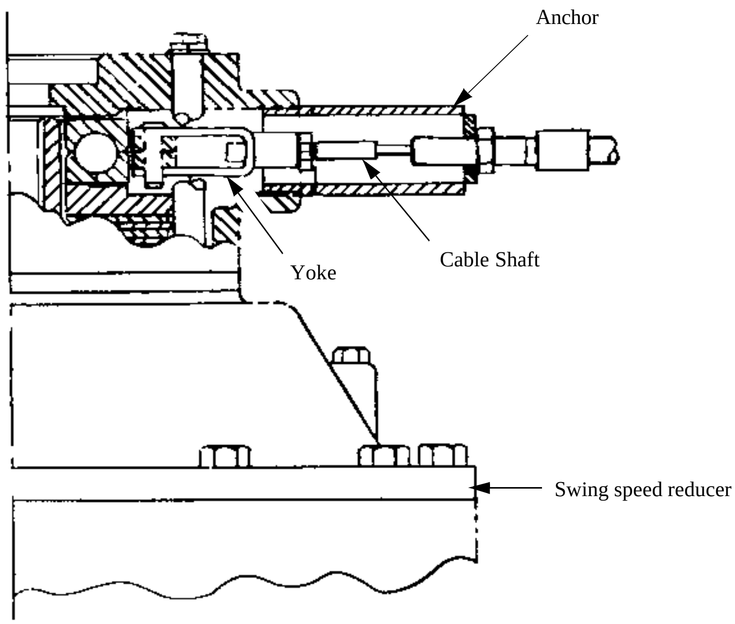


FIGURE 2

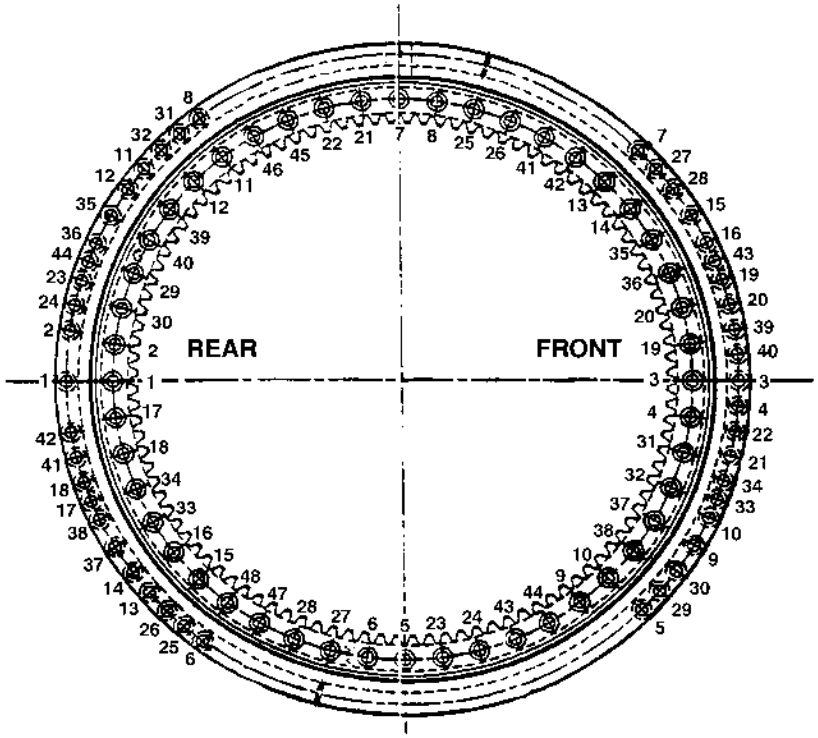
(c) Adjust the pedal end of the swing brake cable by increasing the thread length as indicated in Figure 1 until the swing brake pedal is operating in the 4 to 5 click range. After the adjustments are made, sufficient thread must remain so that all the threads of the jam nuts are engaged.

Note: Any adjustment required on the swing speed reducer end of the swing brake cable will require that the swing brake cable is disconnected from the swing brake pedal.

(d) Set the swing brake and begin to attempt to swing the machine against the swing brake. You should exercise caution in doing this until you know that the swing brake is in good working order and will hold against the swing pressure. Once you have verified that the swing brake is holding, the engine RPM should be brought up to full governed speed slowly.

(e) If the swing brake fails to prevent the boom from rotating or if the swing brake pedal continues to operate in the 6 or 7 click range, the swing brake cable and/or the brake discs *may* need to be replaced.

SWING BEARING



RING GEAR BOLTING SEQUENCE

MAINTENANCE CHECK

It is very important to perform periodic ring gear bolt checks. The bolts MUST BE KEPT TORQUE TIGHTENED to a rating of 980 Ft·Lbs. (1329 NM). After the initial 40 hours of machine operation, check and tighten the bolts. If additional torque is required after the first 40 hours, then recheck each 40 hours until all bolts are found properly torqued. Thereafter, checks should be performed QUARTERLY.

RING GEAR TORQUING

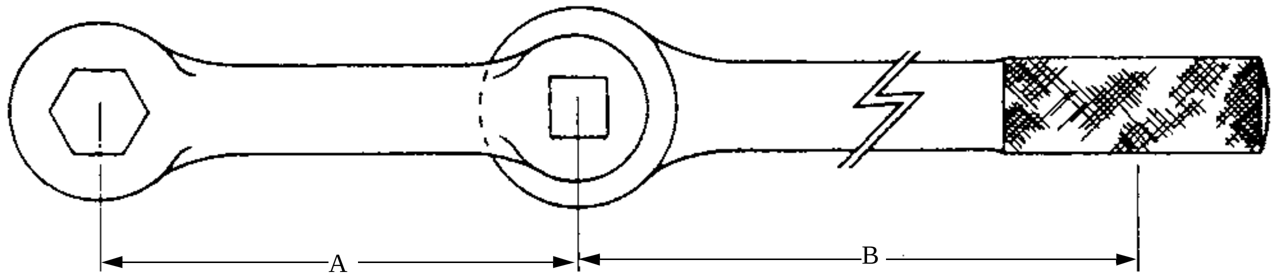
The gear and bearing assembly consists of an inner race and ring gear, an outer race, bearing rollers, spacer and a seal ring. The inner race is bolted to the carrier; the outer race to the turntable.

A number of causes can reduce tension in the bolts when torquing and after use. These include rust on the threads, damaged or rough threads on bolts and nuts, shanks of bolts which hang up on holes, etc. All of these causes have a tendency to absorb the torque when bolts are being tightened.

It is important to make periodic checks of the ring rear bolts. The bolts Must be kept torque tightened.

Torque the inner race first, then the outer race as shown in the bolting sequence. Torque the 1 inch, Grade 8, bolts to 980 Ft. Lbs. (1328 NM)

TORQUE WRENCH EXTENSIONS



In some applications, a standard torque wrench and socket cannot be fitted to the bolt (s) to be tightened because of restricted access. In other instances, the torque value specified cannot be obtained because sufficient force cannot be applied to the standard length wrench. Both of these problems may be solved by the use of appropriate torque wrench extensions - either commercially made or fabricated by the user.

When using an extension, it must be remembered that the wrench torque (the actual torque reading or setting of the wrench) and the wrench force (the force applied to the wrench) must be adjusted to compensate for the added length and produce the desired bolt torque.

Refer to the illustration and formula below when calculating the proper adjusted values for wrench torque, wrench force and bolt torque.

NOTE: If the Torque wrench setting at length "B" would be 600 ft. lb. (813 NM) for capscrews not requiring us of adapter, then the following shows the use of an adapter and the calculation for that setting.

FORMULA

Torque wrench setting (TWS) = (600 ft. lb.) times ("B") / ("B") plus ("A")

= lpq -Plw

EXAMPLE

A = 10.25"
B = 43"

TWS = (600 FT.LB.) X 43 / 42 + 10.25

= 2580 / 53.25

= 485 FT. LB.

WELDING INSTRUCTIONS

Before welding on the unit, contact the factory service department for approval.

ATTENTION

When doing repair welding on your unit take precaution attaching your ground to the component being repaired. This will reduce the chance of arcing through a bearing, cylinder, etc., damaging the component. Paint should be removed from the surface to be used as the "ground" (earth).

ATTENTION

Use necessary precaution when welding around fuel tanks, oil reservoir, batteries, tubing and pressure systems.

ATTENTION

When welding close to glass, cylinder rods, or any polished surface, provide adequate protection from splatter.

ATTENTION

Never weld when the engine is running. Always disconnect the battery cables and applicable grounds before welding.

CAUTION

Do not weld on wet surfaces since this will cause hydrogen embrittlement of the weld.

CAUTION

Always have a fire extinguisher on hand in case of fire. Adequate ventilation and dry area are necessary. Protective clothing should be used and all persons in the welding area should have protection for their eyes. Follow instructions for welding and cutting on paint.

AWS CLASS E7018 Low hydrogen rod for normal repairs on low alloy to medium carbon steel. All position welding, good penetration, and crack resisting up to 80,000 yield. Also suitable for repair of previous intershield welds.

AWS CLASS E11018G Low hydrogen rod for repair on high strength alloy steel such as T-1, 80,000 to 100,000 yield. All position welding, good penetration, and high tensile strength up to 110,000.

Note: *Low hydrogen rod E7018 must be used within four (4) hours upon removal from a freshly opened container or from a storage oven.*

Low hydrogen rod E11018G must be used within 1/2 hour upon removal from its container or from a storage oven.

CAUTION

All welding procedures and welding operator qualifications shall be in accordance with ANSI/AWS D14.3 when welding on load sustaining members (ANSI/ASME B30.5)

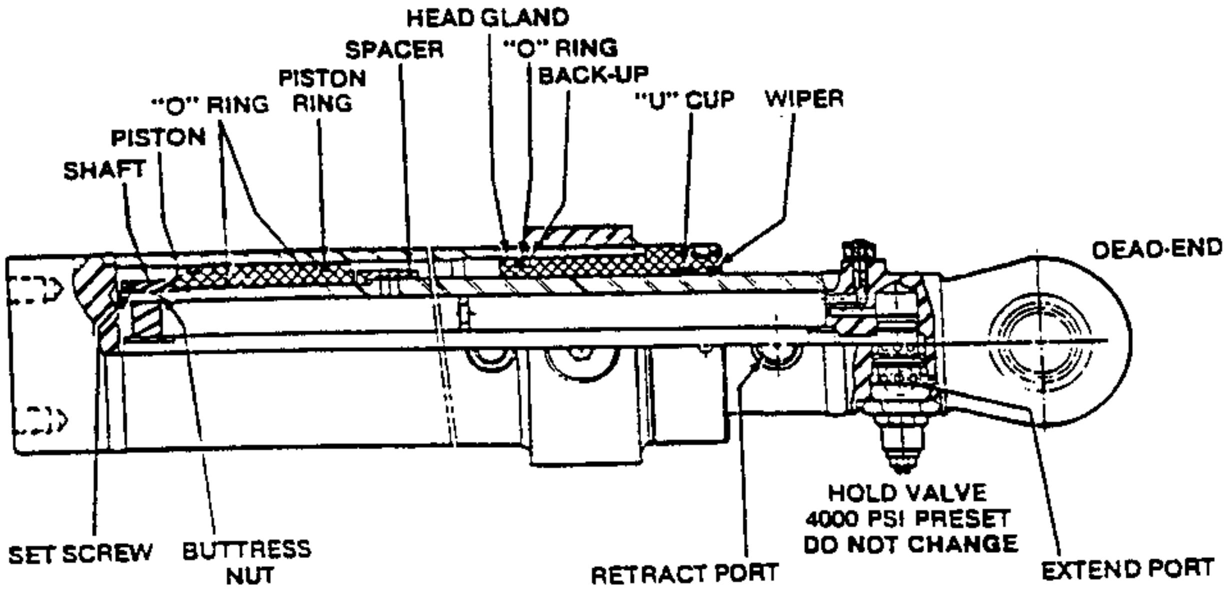
WELDING & CUTTING ON PAINTED SURFACES

WARNING

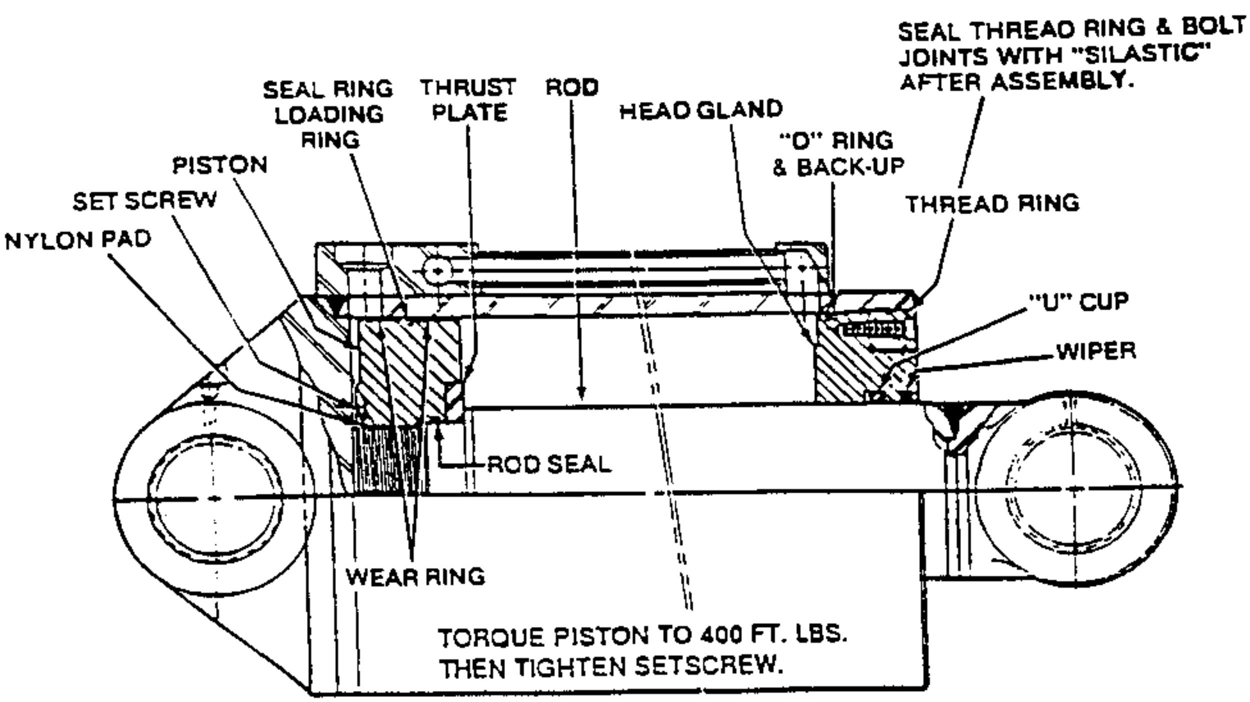
When welding or cutting steel coated with a certain paint systems, the worker is exposed to decomposition products (metal fumes, gases or vapors, particulate) which vary depending on the type of process being used to weld or cut, the nature of the base metal, and the type of coating system. The following control procedures should be utilized when one is welding or cutting coated steel:

- Use a power brush or grinding wheel to strip the coating from the steel in the vicinity where the cut or weld is to be made. Remove the paint far enough from the weld to prevent any remaining paint from becoming heated and bubbling. If this happens, continue to brush or grind the paint away.
- A toxic dust respirator and eye protection should be used while stripping the paint.
- Welder should be outfitted with a fresh air supplied respirator and other personal protective equipment required for welding.
- Other employees should be removed from the area or told to stand back a minimum of 10 feet from the welder. Do not be in direct line with the weld fumes.
- Use a local exhaust hood to remove fumes during the welding or cutting operation if one is available.

HYDRAULIC CYLINDERS



EXTEND CYLINDER



LIFT CYLINDER

HYDRAULIC CYLINDERS MAINTENANCE

HYDRAULIC CYLINDER DISASSEMBLY

GENERAL

Do not disassemble a cylinder unless no other maintenance procedure can correct the problem. All overhaul or new cylinder installations should be done in a clean, dust-free atmosphere with all ports plugged until hose connections are made.

BOOM EXTEND CYLINDERS

The outer case is the "moving" member of the cylinder. The hollow shaft is "stationary". The hollow shaft ports the piston and case end to retract the cylinder while a tube within the "shaft" ports the piston and head gland to extend the cylinder.

Disassemble the boom extend cylinders by the following procedure:

1. Using an adjustable spanner wrench, remove head gland of cylinder. As head gland is loosened, it may be necessary to begin to move rod out of cylinder tube.

2. With head gland fully disengaged, remove as an assembly, piston rod, head gland, and piston assembly.

3. To remove piston, remove the setscrews which secure the piston retaining ring to piston rod.

Note: There are two types of cylinders used on the machine. Both cylinders have setscrews located under the wear ring to retain the piston to the rod.

Note: After removing the piston, the retainer can be removed to reseal the inner tube.

BOOM LIFT CYLINDER

Disassemble the boom lift cylinder by the following procedure:

1. Remove the locking socket head cap screw from the draw ring. With an adjustable spanner wrench, remove the draw ring and head gland.

CAUTION

Failure to remove the locking capscrew may result in serious thread damage.

Note: One turn off, back 1/3 turn alternately.

2. Remove the head gland, shaft, and piston from the case.

3. Remove piston and gland by removing setscrews in retaining collar removing retaining nut. Remove piston and gland from rod. Access to all seal units is now possible.

HYDRAULIC CYLINDER INSPECTION

Wash the cylinder bore and all the components with solvent and make the following inspection:

CYLINDER BORE

For signs of scoring and deep scratches. In the event of any defects, reassemble the entire cylinder and contact your distributor.

CYLINDER SHAFT

For dents, deep scratches, or damaged chrome plating. File any sharp edges on ends of shaft to protect the seals upon reassembly. Always protect the shaft finish when clamping in a vice or when welding against weld splatter.

PISTON RINGS

For cracks or other damage. Particularly check the interlocking ends that they are not missing or broken.

PISTON SEALS

For signs of severe damage. Do not remove unless replacement is necessary.

HYDRAULIC CYLINDERS MAINTENANCE

PISTON & HEAD GLAND

It is not normally necessary to replace the piston, piston rings, or head gland.

HYDRAULIC CYLINDER REASSEMBLY

GENERAL

As cylinder components are reassembled, be certain all rings, seals, spacers, and setscrews required in one step are in place before proceeding to the next step. See Group 39 of the Parts Manual for a complete listing of cylinder parts.

A teflon ring must be installed before the piston ring or wear ring is installed since the teflon ring must first be “walked” into the piston ring groove and then into its own groove. Warm the teflon ring until reasonably flexible and oil the piston ring or wear ring to aid in the installation.

Most piston ring breakage is due to careless or hasty assembly at this point.

BOOM LIFT CYLINDERS

With the piston, piston rod, head gland, retaining ring, and rod eye reassembled as a unit, slide the piston into the cylinder bore. Next, insert and seat the head gland. It may be necessary to drive the head gland into place using a wood block and hammer. In this event, cover the rod with rags or a rubber tube to prevent damage from a glancing hammer blow. The retaining ring is then spun in and tightened to secure the head gland. Install socket head cap screws. The retaining ring should be secured with Loctite Grade 242. Coat both grooves around the thread ring as well as the bolt heads with a “silstic” type silicon sealant to keep moisture out.

Note: When installing the piston ring nut on the piston rod, torque to 400 ft. lbs and then secure with setscrew lock. Use Loctite Grade 242 on ring nut and setscrews.

BOOM EXTENDED CYLINDERS

With the piston, piston rod, head gland, and retaining ring assembled as a unit, slide the piston into the cylinder bore. Next, insert the head gland. It may be necessary to tap the gland into place using a wood block and hammer. In this event, cover the rod with rags or a rubber tube to prevent damage from a glancing hammer blow. The head gland is then spun in and tightened.

Note: Apply Loctite Gr. 242 to piston retaining rings at assembly. Also apply to locking setscrews.

On cylinder, preset nylon plug with a 25 ft. lb. torque, using a Grade 8 cap screw, and install setscrew and setscrew and torque to 15 ft. lbs, three (3) places.

HYDRAULIC CYLINDER OPERATION

As soon as the cylinder is ready to be placed in operation, it should be slowly cycled under no load conditions for several minutes in order to allow the entrapped air within the cylinder to escape to the reservoir and, also facilitate the reforming of the seals which may have temporarily deformed during shipping, storage, or reassembly.

New cylinders may show a slight “drifting” tendency when first used. This is natural, due to one or both of the following causes:

1. Air entrapped in the oil.

2. Seals not yet fully reformed or seated.

“Drifting” should decrease with operation as piston rings and seals “break in” to provide better sealing and the eventual escaping of the trapped air in the oil.

WIRE ROPE AND REEVING

MAINTENANCE

All wire ropes in active service should be inspected daily along with spooling, sheaves, wedge sockets, and any other wire rope fittings for damage. Once weekly a thorough wire rope inspection should be made by a competent inspector. A record should be kept of the inspection on the form provide in section 4.

Refer to ANSI Standard B30.5 for guidelines covering the inspection, maintenance, repair, and replacement of wire rope. Worn, kinked, birdcaged, fatigued, or otherwise damaged wire rope must be removed immediately. Wire rope, when properly installed, lubricated, and employed, will give many hours of satisfactory use. Whereas, a new piece of wire rope can be immediately ruined if misused. Replace any wire rope found to be in unsatisfactory condition.

In addition to damage such as kinking, crushing and broken wires, factors such as corrosion, abrasion, pitting, peening, and scrubbing of outside tires, reduction of rope diameter, the condition of other components, and proper lubrication are considered. Refer to section 4 for wire rope lubricating procedures.

Before installing a new or replacement rope, make certain the rope to be used is the proper type and size. The wrong rope will not function properly and may even be dangerous.

Refer to Section 9 for instructions on inspecting and replacing sheaves.

WIRE ROPE SPECIFICATIONS

MAIN & AUXILIARY WINCH

3/4” (19 mm) dia. 6 x 19 or 6 x 37
IWRC regular lay wire rope
Minimum Breaking Strength 25.6 Tons (23.3 MT)

MAIN & AUXILIARY WINCH OPTIONAL HOIST LINE

3/4” (19 mm) rotation resistant
compacted strand 34 x 7 Grade 2160
Minimum Breaking Strength 34.5 Tons (31.4 MT)

CAUTION

The use of non-rotating 18 x 7 class wire rope is not recommended in multiple reeving applications and, if used for applications involving single part line, must not be used with loads exceeding one fifth (1/5) the rated breaking strength. The inner wires are generally the first to fail on this class of rope making it very difficult to inspect as broken wires cannot be seen. Refer to ANSI B30.5, Section 5-2.4 for the necessary inspection procedure and replacement criterion.

If non-rotating or spin resistant rope is used on this crane, the rope must be replaced if two or more wires are found broken in one lay of the rope.

CABLE REEVING

When reeving the machine for any job, remember that hoisting and lowering speeds decrease as the number of parts of line increases. For the most efficient use of the machine, it is desirable to use the minimum number of required parts for lifting the anticipated loads.

CAUTION

Never use less than the number of parts called for by the load rating chart. The minimum required number of parts is determined by referring to the load rating chart.

This machine incorporates a “Quick Reeving” boom head and block which do not require removal of the wedge and socket from the rope in order to change the reeving. Removal of two pins in the boom head and three in the hook block will allow the wedge and socket to pass through.

CAUTION

If a socket is changed or replaced, or if you are changing hook block weights; it is important to use the correct socket.

SPOOLING WIRE ROPE ON DRUMS

Care must be exercised when installing wire rope on the winch drum. Improper spooling can result in winch damage through crushing, kinking, doglegs, abrasion, and cutting. Poorly installed wire rope will also adversely affect the operating characteristics of the machine by causing uneven application of force and motion. This can cause premature fatiguing and failure of the rope.

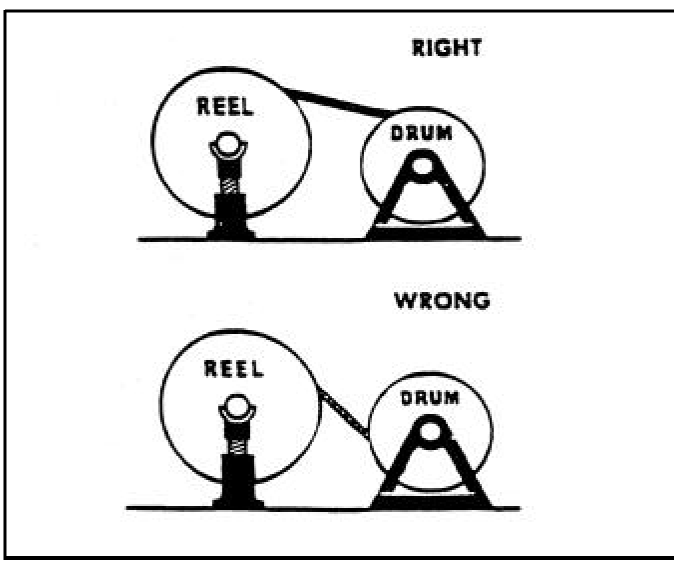
Thoroughly inspect and clean the winch before proceeding with the installation. CHeck the lagging and drum flanges for cracks, breaks, and excessive wear. Deformed or outsized drum and excessive undercutting at the base of the flange also indicate the repair or replacement of the drum is necessary.

Check the bearings for excessive wear or play.

After correcting any defects revealed by the inspection and determining that the winch is in good operating condition, spool the wire rope as follows:

Mount the cable shipping reel vertically on jacks or a suitable supporting structure, with a pipe or bar through the reel center. The cable should be drawn from the top of the reel, as shown, in order to avoid reverse bending as it is spooled onto the winch drum.

If cable is wound from the storage reel onto the drum, the reel should be rotated in the same direction as the hoist.



Apply breaking force to the reel flange in order to prevent overrun as the rope is being drawn off. Loops formed by overrun can cause kinks and doglegs in the rope, resulting in damage and premature rope failure. A timber or block forced against the shipping reel flange can be used to provide the required braking force.

Install cable on the winch drum in accordance with the following procedure.

1. Position the cable over the boom nose sheave and route back to the winch drum.
2. Position the winch drum with the cable anchor slot on top.
3. Insert cable through slot and position around the cable wedge.
4. Position the anchor wedge in the drum slot; pull firmly on the free end of the cable to secure the wedge.
5. Slowly rotate the drum, ensuring the first layer of cable is evenly wound onto the drum.
6. Install the remainder of cable, as applicable.

The end of the cable should be even with the bottom of the anchor wedge.

Note: If the wedge does not seat securely in the slot, carefully tap the top of the wedge with a mallet.

CABLE SOCKETS

CAUTION

The wrong cable wedge could permit the wire rope to work loose and detach itself from the drum, possibly causing property damage or personal injury.

Tension the wire rope by braking the shipping reel and slowly operate the winch in the raise mode to wind the cable onto the winch drum. As the spooling proceeds, make sure that adjacent turns are tight against one another. A lead or brass hammer may be used to tap the rope over against preceding turns. Tight winding on the drum is absolutely essential.

CAUTION

Never use a steel hammer or punch bar to move the rope on the drum. These tools can easily damage the rope.

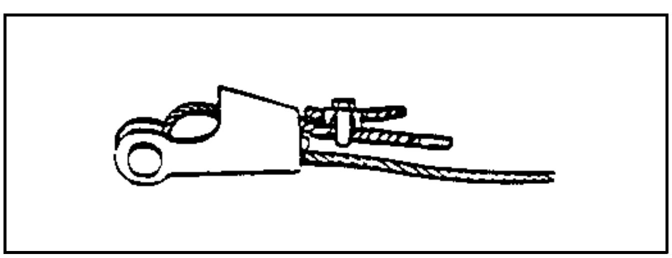
After the wire rope is wound onto the winch drum, reeve the cable as desired.

CAUTION

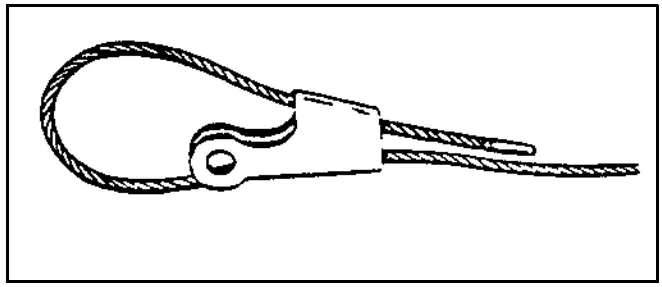
Use only factory supplied sockets, wedges, and pins of the proper size; make no substitutions.

Follow the procedure below when installing wedge type sockets on wire rope. Be certain the correct socket and wedge are used.

1. Lead the rope through the socket, form a large loop and draw the rope end back through the socket. A length of rope equal to at least one rope lay should be drawn back through.

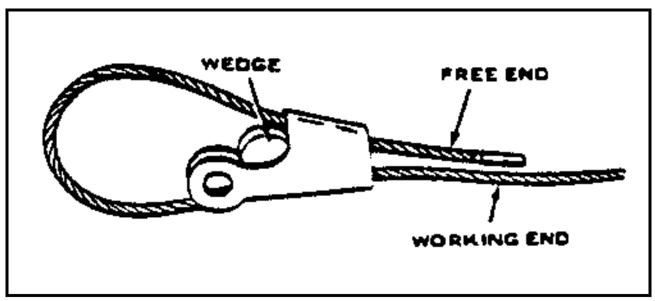


2. Insert the wedge and allow the rope strands to adjust around it.



3. Seat the wedge and loop just tightly enough to allow handling by attaching the socket to a strong support and engaging the winch to take a strain on the rope.

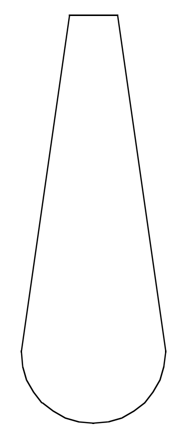
4. Final seating of the wedge is accomplished by making lifts of gradually increasing loads. Avoid imposing shock loading on the rope until the wedge is firmly in place.



5. After the wedge has been firmly seated, a short length (6 inches) of the cable should be secured to the free end of the wire rope to act as a stop as shown. Do not clamp the free end to the load supporting end as this will weaken the rope.

CABLE SOCKETS

CABLE SOCKETS AND WEDGES

WHERE USED	PART NUMBER	
3/4" CABLE SOCKET & WEDGE 3/4" SOCKET WEDGE	1234-44 218534	

INDEX

SECTION 7

SUBJECT **PAGE**

Machines being placed in storage must be adequately protected from deterioration during the period of idleness. This will ensure that they can be restored to active service with a minimum effort.

Before removing this hydraulic crane from service for extended periods, it should be prepared for storage as prescribed in the following paragraphs. In general, three (3) major components must undergo preparation. These are the Machine Proper, the Engine and the Transmission. The specific procedure to be followed depends upon the expected period of storage.

SHORT TERM STORAGE - 30 DAYS OR LESS
Short term storage requires minimal preparation.

The **MACHINE** should be thoroughly cleaned, lubricated in accordance with Section 4, and painted surfaces retouched where the paint has deteriorated. exposed portions of all hydraulic cylinders should be coated with multipurpose grease. Coat unpainted metal surfaces with multipurpose grease after removing any rust accumulations.

The **ENGINE** should be prepared as prescribed on page 7-2, the topic “Engine Storage”.

The **TRANSMISSION** should be prepared as prescribed on page 7-4, the topic “Transmission Storage”.

LONG TERM STORAGE - 30 DAYS OR MORE

Long term storage requires greater preparation than short term storage and must be undertaked with greater care.

The **MACHINE** should be prepared as follows:

1. Perform the short term machine storage preparation, making certain that All points with grease fittings are liberally lubricated.

2. Drain and refill the swing reducer, winch(es), axle differentials, planetary hubs and the hydraulic reservoir. Refer to page 4-19 when servicing the reservoir.

3. Distribute the new hydraulic fluid to all parts of the system by operating all function.

4. Clean and tape the battery cables after removing and storing the battery.

5. Coat the external ring gear of the swing bearing with oper gear lubricant.

6. Fill the hydraulic reservoir to the top *AFTER THE MACHINE IS PARKED IN ITS STORAGE SPOT.*

7. Coat wire rope with lubricant.

8. Coat exposed cylinder rods with grease.

The **ENGINE** should be prepared as prescribed on page 7-2, the topic “Engine Storage”.

The TRANSMISSION should be prepared as prescribed on page 7-4, the topic “Transmission Storage.”

ENGINE STORAGE

PREPARING ENGINE FOR STORAGE - When an engine is to be stored or removed from operation for a period of time, special precautions should be taken to protect the interior and exterior of the engine, transmission, and other parts from rust accumulation and corrosion. The parts requiring attention and the recommended preparations are given below.

It will be necessary to remove all rust or corrosion completely from any exposed part before applying a rust preventive compound. Therefore, it is recommended that the engine be processed for storage as soon as possible after removal from operation.

The engine should be stored in a building which is dry and can be heated during the winter months. Moisture absorbing chemicals are available commercially for use when excessive dampness prevails in the storage area.

TEMPORARY STORAGE (30 DAYS OR LESS)
To protect an engine for a temporary period of time proceed as follows:

1. Drain the engine crankcase.

2. Fill the crankcase to the proper level with the recommended viscosity and grade of oil.

3. Fill the fuel tank with the recommended grade of fuel oil. Operate the engine for two minutes at 1200 rpm and no load.

NOTE: Do not drain the fuel system or the crankcase after this run.

4. Check the air cleaner and service it, if necessary as outlined under *Air System*.

5. If freezing weather is expected furing the storage period, add a high boiling point type antifreeze solution in accordance with the manufacturer's recommendations. Drain the raw water system and leave the drain cocks open.

6. Clean the entire exterior of the engine (except the electrical system) with fuel oil and dry it with air.

7. Seal all of the engine openings. The material used for this purpose must be waterproof, vaporproof and possess sufficient physical stength to resist puncture and damage fro m the expansion of entrapped air.

An engine prepared in this manner can be returned to service in a short time by removing the seals at the engine openings, checking the engine coolant, fuel oil, lubricating oil, transmission, and priming the raw water pump, if used.

EXTENDED STORAGE (30 DAYS OR MORE)
When An Engine Is To Be Removed From Operation For An Extended Period Of Time,prepare It as follows:

1. Drain and thoroughly flush the cooling systemwith clean, soft water

2. Refill the cooling system with clean, soft water.

3. Add a rust inhibitor to the cooling system (re fer to page 4-7, "Corrsion Inhibitor).

4. Remove, check and reconditon the injectors, if necessary, to make sure they will be readyt to operate when the engine is restored to service.

5. Reinstall the injectors in the engine, time them, and adjust the valve clearance.

6. Circulate the coolant through the entire system by operating the engine until normal operating temperature is reached (160°F. to 185°F).

7. Stop the engine.

8. Remove the drain plug and completely drain the engine crankcase. Reinstall and tighten the drain plug. Install new lubricating oil filter elements and gaskets.

9. Fill the crankcase to the proper level with a 30-weight preservative lubricating oil MIL-L-21260, Grade 2 (P10), or equivalent.

10. Drain the engine fuel tank.

11. Refill the fuel tank with enough rust preventive fuel oil such as Americal Oil Diesel Run-In Fuel (LH 4089), Mobil 4Y17, or equivalent, to enable the engine to operate 10 minutes.

12. Drain the fuel filter and strainer. Remove the retaining bolts, shells and elements. Discard the used elements and gaskets. Wash the shells in clean fuel oil and insert new elements. Fill the cavity between the element and shell about two-thirds full of the same rust preventive compound as used in the fuel tank and reinstall the shell.

13. Operate the engine for 5 minutes to circulate the rust preventive throughout the engine.

14. Refer to page 4-6 and service the air cleaner.

15. With an all-purpose grease such as Shell Alvania No. 2, or equivalent, lubricate the clutch throwout bearing, clutch pilot bearing, drive shaft main bearing, clutch release shaft, and the outboard bearings (if so equipped).

16. Remove the inspection hole cover on the clutch housing and lubricate the clutch release lever and link pins with a hand oiler. Avoid getting oil on the clutch facing.

17. Apply a *non-friction* rust preventive compound, to all exposed parts. If it is convenient, apply the rust preventive compound to the engine flywheel. If not, disengage the clutch mechanism to prevent the clutch disc from sticking to the flywheel.

CAUTION

Do not apply oil, grease or any wax base compound to the flywheel. The cast iron will absorb these substances which can “sweat” out during operation and cause the clutch to slip.

18. Drain the engine cooling system (tag cap).

19. The oil may be drained from the engine crankcase if so desired. If the oil is drained, reinstall and tighten the drain plug (tag cap).

20. Remove and clean the battery and battery cables with a baking soda solution and rinse them with fresh water. Store the battery in a cool (never below 32°F.) dry place. Keep the battery fully charged .

21. Insert heavy paper strips between the pulleys and belts to prevent sticking.

22. Seal all of the openings in the engine, including the exhaust outlet, with moisture resistant tape. Use cardboard, plywood or metal covers where practical.

23. Clean and dry the exterior painted surfaces of the engine. Spray the surfaces with a suitable liquid automobile body wax, a synthetic resin varnish or a rust preventive compound.

24. Cover the engine with a good weather-resistant tarpaulin or other cover if it must be stored outdoors. A clear plastic cover is recommended for indoor storage.

The stored engine should be inspected periodically. If there are any indications of rust or corrosion, corrective steps must be taken to prevent damage to the engine parts. Perform a complete inspection at the end of one year and apply additional treatment as required.

RESTORING ENGINE TO SERVICE

1. Remove the valve rocker cover(s) and pour at least one-half gallon of oil, of the same grade as used in the crankcase, over the rocker arms and push rods.

2. Reinstall the valve rocker cover(s).

3. Remove the covers and tape from all of the openings of the engine, fuel tank, and electrical equipment. *Do not overlook the exhaust outlet.*

4. Wash the exterior of the engine with fuel oil to remove the rust preventive.

5. Remove the rust preventive from the flywheel.

6. Remove the paper strips from between the pulleys and the belts.

7. Check the crankcase oil level. Fill the crankcase to the proper level with the heavy-duty lubricating oil recommended under *Lubricating Oil Specifications*.

8. Fill the fuel tank with the fuel specified under *Diesel Fuel Oil Specifications*.

9. Close all of the drain cocks and fill the engine cooling system with clean soft water and a rust inhibitor. If the engine is to be exposed to freezing temperatures, add a high boiling point type antifreeze solution to the cooling system (the antifreeze contains a rust inhibitor).

10 Install and connect the battery.

11. Service the air cleaner as outlined under *Air System*.

12. Prepare the generator for starting.

13. Remove the inspection hole cover and inspect the clutch release lever and link pins and the bearing ends of the clutch reliease shaft. Apply engine oil sparingly, if necessary to these areas.

14. After all of the preparations have been completed, start the engine. The small amount of rust preventive compound which remains in the fuel system will cause a smoky exhaust for a few minutes.

NOTE: Before subjecting the engine to a load or high speed, it is advisable to check the engine tune-up.

TRANSMISSION STORAGE

PRESERVATIVE SELECTION When transmissions are to be stored or remain inactive for extended periods of time, specific preservative methods are recommended to prevent rust and corrosion damage. The length of storage will usually determine the preservative method to be used. Various methods are described below.

STORAGE NEW UNITS
New units contain preservative oil when shipped for Funk and can be safely stored for 6 weeks without further treatment. Refer to the Funk Transmission manual for additional information.

STORAGE, 30 DAYS TO 1 YEAR - WITHOUT OIL

1. Drain Oil.

2. Seal all openings and breathers, except oil drain hole, with moisture-proof cover or tape.

3. Coat all exposed, unpainted surfaces with Nox Rust X-110.

4. Atomize or spray 4 ounces of Nox Rust VCI No. 10 oil, or equivalent, into the transmission through the oil drain hole. Install the drain plug.

5. If additional storage time is required, (3) and (4) above should be repeated at yearly intervals.

***Nox Rust is a preservative additive manufactured by the Daubert Chemical Company, Chicage, Illinois. Motorstor is covered by US Military Specifications MIL-L-46002 (ORD) and MIL-1-23310 (WEP).**

RESTORING TRANSMISSION TO SERVICE

1. If Nox Rust, or equivalent, was used in preparing the transmission for storage, use the following procedures to restore the unit to service.

2. Remove the tape from openings and breather.

3. Wash off all the external grease with solvent.

4. Add hydraulic transmission fluid, type C3 to proper level.

NOTE: It is not necessary to drain C3 oil and Nox Rust mixture from the transmission.

5. If Nox Rust or equivalent, was not used in preparing the transmission for storage, use the following procedures to restore the unit to service.

6. Remove the tape from openings and breathers.

7. Wash off all the external grease with solvent.

8. Drain oil.

9. Install a new oil filter element(s).

10. Refill transmission with hydraulic transmission fluid, type C3 to proper level.

RESTORATION TO SERVICE

Refer to page 7-4, “Restoring Engine to Service”, and page 7-5 and 7-6, “Restoring Transmission to Service”, for the procedures required to restore these components to service.

Remove the **MACHINE** from storage via the following procedure:

1. Remove preservative lubricants from all surfaces.

2. Check all fluid levels, adding or draining as required.

3. Lubricate the machine according to Section 9, making certain that all points with grease fittings are lubricated.

4. Make a thorough visual inspection of the entire machine, placing special emphasis on the condition of all hydraulic hoses.

CHROME CYLINDER ROD STORAGE

Hard chrome plating is primarily applied to steel cylinder rods for its wear resistant properties, although it does provide considerable corrosion resistance as well. Once the chrome-plated rod is assembled into a cylinder and put into service, the hydraulic fluid on the surface of the rod provides all the corrosion resistance required for the rod during its life cycle. As a cylinder cycles, hydraulic fluid is driven into any surface cracks that exist in the chrome plate. When these cracks are filled with hydraulic fluid, moisture or corrosive fluids can not penetrate the cracks. However, some machining and cleaning operations can negatively impact the future corrosion resistance of chrome-plated shafting. For example, additives such as chlorine, sulfur, and sodium found in Extreme Pressure (EP) coolants and some washing solutions are known rust accelerates and can strip chrome plating from the base metal. Cleaning processes, such as phosphate washing are also known to be detrimental to the corrosion resistance of hard chrome plated shafting.

If the rod is not periodically cycled and is subject to a corrosive environment, moisture and oxygen can work its way down through the chrome layer and begin to corrode the base metal. Brand new equipment may be stored outside for a considerable period of time at the equipment dealership before it is sold. During these times, a protective barrier must be applied to the exposed cylinder rod. This protective barrier will preserve the integrity of the chrome plating by preventing the elements of corrosion from getting to the metal substrate.

Cylinders should be stored in the retracted position, if at all possible. The steps outline below cover the procedures to be followed for **protecting New Equipment** from corrosion if it must be stored in the extended position:

1. Position the equipment as it will be stored and identify all the exposed portions of the chrome plated cylinder rods.

2. Clean any dirt and dust from the exposed portions of the cylinder rods using a dry cloth or a cloth which has been dampened with an appropriate solvent. Do not use caustics or acids.

3. Apply a thin coating of **"Ferro-Kote 5856-BF"** to the exposed surfaces of the chrome plated cylinder rods. The ferro-Cote may be thinned using a 40% Kerosene or no. 1 fuel oil mixture.

4. Inspect the cylinder rod surfaces and reapply at three to six month intervals.

5. If the equipment is to be moved and then stored again for an extended period of time or if the cylinder is cycled, steps 1 thru 4 should be repeated for all cylinder rods that were exposed.

   *Ferro-Kote 5856-BF is a product of Quaker Chemical Company, Conshohocken, PA 19428

For the **protection of Older Equipment** that is to be stored, the procedure outlined above can be used, but greater attention to cleaning the exposed portions of each cylinder rod is required. Solvent applied with plastic or copper wool can be used, but **abrasives such as sandpaper should never be used** to clean the exposed surfaces of the cylinder rod. If surface damage to the chrome plate is discovered, the frequency of corrosion barrier applications should be increased.

Note: Caution must be used when cleaning equipment in service with high pressure washes. Soaps or chemicals containing chlorines or other corrosive elements should be avoided. Cylinders should be cleaned in a retracted position as not to expose rods to the chemicals. Cylinders should be cycled immediately following the wash. If rods are to be stored in the extended position, refer to steps 1-4 above.

INDEX

SECTION 8

SUBJECT **PAGE**

CONVERSION TABLES

DECIMAL AND METRIC EQUIVALENTS OF FRACTIONS OF AN INCH

Fractions of an inch	Decimals of an inch	Millimeters	Fractions of an inch	Decimals of an inch	Millimeters
1/64	.0156	0.397	33/64	.5156	13.097
1/32	.0313	0.794	17/32	.5313	13.494
3/64	.0469	1.191	35/64	.5469	13.891
1/16	.0625	1.588	9/16	.5625	14.287
5/64	.0781	1.985	37/64	.5781	14.684
3/32	.0938	2.381	19/32	.5938	15.081
7/64	.1094	2.778	39/64	.6094	15.478
1/8	.1250	3.175	5/8	.6250	15.875
9/64	.0406	3.572	41/64	.6406	16.272
5/32	.1563	3.969	21/32	.6563	16.688
11/64	.1719	4.366	43/64	.6719	17.085
3/16	.1875	4.762	11/16	.6875	17.462
13/64	.2031	5.159	45/64	.7031	17.859
7/32	.2188	5.556	23/32	.7188	18.256
15/64	.2344	5.953	47/64	.7344	18.653
1/4	.2500	6.350	3/4	.7500	19.050
17/64	.2656	6.747	49/64	.7656	19.447
9/32	.2813	7.144	25/32	.7813	19.843
19/64	.2969	7.541	51/64	.7969	20.240
5/16	.3135	7.937	13/16	.8125	20.637
21/64	.3281	8.334	53/64	.8281	21.034
11/32	.3438	8.731	27/32	.8438	21/430
23/64	.3594	9.128	55/64	.8594	21/827
3/8	.3750	9.525	7/8	.8750	22.224
25/64	.3906	9.922	57/64	.8906	22.621
13/32	.4063	10.319	29/32	.9063	23.018
27/64	.4219	10.716	59/64	.9219	23.415
7/16	.4375	11.12	15/16	.9375	23.812
29/64	.4531	11.509	61/64	.9531	24.209
15/32	.4688	11.906	31/32	.9688	24.606
31/64	.4844	12.303	63/64	.9844	25.003
1/2	.5000	12.700	1	1.0000	25.400

LIQUID WEIGHTS AND MEASURES

LIQUID MEASURE

4 gills	equals	1 pint
2 pints	“	1 quart
4 quarts	“	1 gallon
7.48 gallons	“	1 cu. ft.
240 gallons of water	“	1 Ton
340 gallons of gasoline	“	1 Ton

MEASURES OF WEIGHTS

16 ounces	equals	1 pound
2000 pounds	“	1 short ton
2240 pounds	“	1 long ton
100 cu. feet	"	1 register ton
40 cu. feet	“	1 U.S. shipping ton

CIRCULAR MEASURE

60 seconds	equals	1 minute
60 minutes	“	1 degree
90 degrees	“	1 quadrant
360 degrees	“	circumference

METRIC EQUIVALENTS

LIQUID MEASURE

1 litre	equals	.0353 cu. ft.
1 litre	“	.2642 gallon
1 litre	“	61.023 cu. in.
1 litre	“	2.202 lbs. of water(62×F.)
1 cu. foot	“	28.32 litres
1 gallon	“	3.785 litres
1 cu. inch	“	.0164 litre

MEASURE OF WEIGHTS

1 gram	equals	.0353 ounce
1 kilogram	“	2.205 lbs.
1 ounce	“	28.35 grams
1 pound	“	.454 kilogram
1 ton	“	.907 metric ton

ELECTRICAL UNITS

1 kilowatt	equals	1.34 H.P.
1 horsepower	“	746 watts

SURVEYOR’S MEASURE

7.92 inches	equals	1 link
100 links	“	66 feet or 4 rods or 1 chain
80 chains	“	1 mile

AVERAGE WEIGHT OF MATERIALS
Lb. per Cu. Ft.

METALS, ALLOYS, ORES

Aluminum, Cast-Hammered	165
Brass, Cast-Rolled	534
Bronze	509
Copper, Cast-Rolled	556
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Iron, Gray-Cast	442
Iron Slag	172
Lead	710
Manganese	475
Mercury	847
Nickel	537
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Tin, Cast-Hammered	459
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TORQUE RATINGS

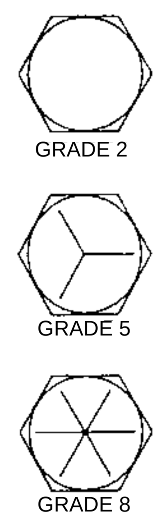
ES - 100.0
TORQUE RATINGS
FOR
DRY - UNCOATED FASTENERS

TORQUE VALUES TO BE WITHIN ± 5%
ALL FIGURES IN FOOT POUND

THIS TABLE DOES NOT APPLY TO HYDRAULIC CONNECTIONS. WHEN TORQUING HYDRAULIC CONNECTIONS REFER TO ES-100.1

NOM. DIA. IN.	GRADE 2	GRADE 5	GRADE 8
1/4	6 - * 4	8	12
5/16	12 - * 7	20	25
3/8	20 - * 12	30	45
7/16	35 - * 20	50	75
1/2	50 - * 30	80	110
9/16	75 - * 45	115	160
5/8	100 - * 60	160	225
3/4	180 - * 110	280	400
7/8	175	450	640
1	265	680	970
1-1/8	375	840	1,380
1-1/4	530	1,200	1,930
1-3/8	700	1,570	2,540
1-1/2	930	2,080	3,380
1-3/4	1,460	2,090	5,300
2	2,200	3,200	7,990
2-1/4	3,200	5,350	11,690
2-1/2	4,400	7,300	15,990

BOLT HEAD MARKING



The above information was compiled for U.N.C. Threaded Fasteners.

NOTE: ** = Torque Values For Bolts And Screws Longer Than 6”*

Fasteners as supplied by the vendor are considered not lubricated.

TORQUE RATINGS

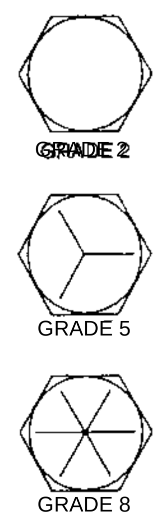
ES - 100.1
TORQUE RATINGS
FOR
LUBRICATED OR PLATED FASTENERS

TORQUE VALUES TO BE WITHIN ± 5%
ALL FIGURES IN FOOT POUND

REFER TO THIS TABLE WHEN TORQUING HYDRAULIC CONNECTIONS (Piping & Cylinders).

NOM. DIA. IN.	GRADE 2	GRADE 5	GRADE 8
1/4	5 - * 3	7	10
5/16	9 - * 5	14	20
3/8	16 - * 9	25	35
7/16	25 - * 15	40	55
1/2	40 - * 20	60	85
9/16	55 - * 30	85	120
5/8	75 - * 45	120	170
3/4	135 - * 80	210	300
7/8	130	340	485
1	200	515	720
1-1/8	280	635	1,030
1-1/4	400	890	1,450
1-3/8	520	1,175	1,900
1-1/2	695	1,560	2,530
1-3/4	1,100	1,825	3,980
2	1,650	2,750	6,000
2-1/4	2,400	4,000	8,760
2-1/2	3,300	5,500	12,000

BOLT HEAD MARKING



The above information was compiled for U.N.C. Threaded Fasteners.

NOTE: *If threads are not lubricated prior to assembly or are not plated use Torque Spec. ES-100.0*

** = Torque Values for Bolts and Screws longer than 6”*

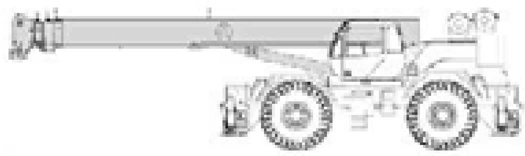
Fasteners as supplied by the vendor are considered not lubricated.

TEREX

ROUGH TERRAIN CRANE

RT700

Rough Terrain Crane Specifications | RT700



STANDARD BOOM EQUIPMENT

BOOM

40-126' (10.67-33.53 m), four section full power boom. Telescoping is mechanically synchronized with single lever control. The synchronization system consists of a single telescope cylinder and high strength leaf chains to extend and retract the third section and the tip section. The boom is a high-strength four plate design, welded inside and out with anti-friction slide pads. Boom side plates are made with stamped impressions to reduce weight and increase strength. A single boom hoist cylinder provides for boom elevation of -4 to 78 degrees. Maximum tip height 134' (40.87 m).

BOOM HEAD

Welded to fourth section of boom. Five or six metallic load sheaves and two idler sheaves mounted on heavy duty, anti-friction bearings. Quick reeving boom head. Provisions made for side-stow jib mounting.

OPTIONAL BOOM EQUIPMENT

JIBS

32' (9.68 m) side stow swing-on one-piece lattice type jib. Single nylon sheave mounted on anti-friction bearing. Jib is offsettable at 0°, 15°, or 30°. Maximum tip height is 165' (50.42 m).
33-57' (10.15-17.30 m) side stow swing-on lattice type jib. Single nylon sheave mounted on anti-friction bearing. Jib is extendible to 57' (17.30 m) by means of a 25' (7.62 m) manual pull-out tip section, roller supported for ease of extension. Jib is offsettable at 0°, 15°, or 30°. Maximum tip height is 190' (57.91 m).

BOOM HEAD

Welded to fourth section of boom. Five or six nylon load sheaves and two idler sheaves mounted on heavy duty, anti-friction bearings. Quick reeving boom head. Provisions made for side-stow jib mounting.

AUXILIARY BOOM HEAD

Removable auxiliary boom head has single nylon sheave mounted on anti-friction bearing. Removable pin-type rope guard for quick reeving. Installs on main boom peak only. Removal is not required for jib use.

HOOK BLOCK

Five metallic sheaves on anti-friction bearings with hook and hook latch. Quick reeving design does not require removal of wedge and socket from rope.

HOOK & BALL

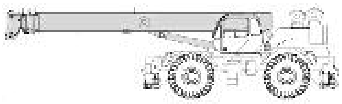
12 ton (10.9 mt) top swivel ball with hook and hook latch.

TEREX

ROUGH TERRAIN CRANE

RT700

STANDARD UPPERSTRUCTURE EQUIPMENT



UPPERSTRUCTURE FRAME

All welded one-piece structure fabricated with high tensile strength alloy steel. Counterweight is bolted to frame.

TURNTABLE CONNECTION

Swing bearing is a single row, ball type, with internal teeth. The swing bearing is bolted to the revolving upperstructure and to the carrier frame.

SWING

A hydraulic motor drives a double planetary reduction gear for precise and smooth swing function. Swing speed (no load) is 2.2 rpm.

SWING BRAKE

Heavy duty multiple disc swing brake is mechanically actuated from operator's cab by foot pedal. Brake may be locked on or used as a momentary brake. A 360° mechanical house lock is standard.

RATED CAPACITY INDICATOR

Rated Capacity Indicator with visual and audible warning system and automatic function disconnects. Second generation pictographic display includes: boom radius, boom angle, boom length, allowable load, actual load, and percentage of allowable load registered by bar graph. Operator settable alarms provided for swing angle, boom length, boom angle, tip height, and work area exclusion zone. Anti-two block system includes audio/visual warning and automatic function disconnects.

OPERATORS CAB

Environmental cab with all steel construction, optimum visibility, tinted safety glass throughout, and rubber floor matting is mounted on vibration absorbing pads. The cab has a sliding door on the left side, framed sliding window on the right side, hinged tinted all glass skylight and removable front windshield to provide optimum visibility of the load open or closed. Hot air defroster keeps windshield clear. Acoustical foam padding insulates against sound and weather. The deluxe six-way adjustable seat is equipped with a mechanical suspension and includes head and arm rests.

CONTROLS

Armrest mounted dual axis controls for winch(s), swing, and boom elevation. Winch rotation indication incorporated into control handles. Armrest swings up to improve access and egress. Vernier adjustable hand throttle included. Steering column mounted turn signal, wiper, and shift controls. Switches include ignition, engine stop, lights, horn, roof window wiper, defroster, steering mode, parking brake, outriggers, 360° house lock, etc. Horn and winch speed shift switches are mounted in the levers. Foot control pedals include swing brake, boom telescope, service brake, and accelerator.

INSTRUMENTATION AND ACCESSORIES

In-cab gauges include air pressure, bubble level, engine oil pressure, fuel, engine temperature, voltmeter, transmission temperature, and transmission oil pressure. Indicators include low air, high water temperature, low oil pressure, high transmission temperature, and low coolant level audio/visual warning, hoist drum rotation indicator(s), and Rated Capacity Indicator. Accessories include fire extinguisher; light package including headlights, taillight, brake lights, directional signals, four-way hazard flashers, dome light, and back-up lights with audible back-up alarm; wind-shield washer/wiper; skylight wiper; R.H. and L.H. rear view mirrors; dash lights; and seat belt. Circuit breakers protect electrical circuits.

HYDRAULIC CONTROL VALVES

Valves are mounted on the rear of the upper structure and are easily accessible. Valves have electric/hydraulic operators and include one pressure compensated two spool valve for boom elevation and telescope. One pressure compensated two spool valve for main and auxiliary winch, and one single spool valve for swing. System provides for simultaneous operation of all crane functions. High pressure regeneration feature provides 2-speed boom extension. Quick disconnects are provided for ease of installation of pressure check gauges.

OPTIONAL EQUIPMENT

Auxiliary Winch • Single axis armrest mounted controllers • LP Heater/Defroster • Hydraulically powered Air Conditioner with or without hydraulic heater' Diesel Heater/Defroster • Work Lights, Rotating Beacon

STANDARD CARRIER EQUIPMENT

CARRIER CHASSIS

Chassis is Terex designed with four-wheel drive and four-wheel steer (4X4X4). Has box-type construction with reinforcing cross members, a precision machined turn table mounting plate and integrally welded outrigger boxes. Decking has anti-skid surfaces, including between the frame rails, a lockable front tool storage compartment, and access steps and handles on the left and right sides and on all four corners. Lights are recessed into the outrigger boxes for protection. Air reservoir drains are collected in an easily accessible central location.

AXLES AND SUSPENSION

Rear axle is a planetary drive/steer type with 10.5" (0.26m) of total oscillation. Automatic oscillation lockouts engage when the superstructure is swung 10° either direction. Front axle is a planetary drive/steer type, rigidly mounted to the frame for increased stability.

STEERING

Hydraulic four-wheel full power steering for two-wheel, four-wheel coordinated, or four-wheel crab steer is easily controlled by steering wheel. A rear axle centering light is provided.

	Turning Radius: (to CL of outside tire)	**Curb Clearance Radius**
Two-wheel:	41' 7" (12.7 m)	43' 2" (13.2 m)
Four-wheel:	22' 10" (7.0 m)	24' 7" (7.5 m)

TRANSMISSION

Range shift type power-shift transmission with integral torque converter provides 6 speeds forward and 6 speeds reverse with neutral safety start. Four wheel drive engages automatically with low range and two wheel drive with high range. A remote mounted oil filter provides easy access. Automatic pulsating back-up alarm.

TEREX

ROUGH TERRAIN CRANE

RT700

STANDARD CARRIER EQUIPMENT (CONTINUED)

MULTI-POSITION OUT & DOWN OUTRIGGERS

Fully independent hydraulic outriggers may be utilized fully ex¬tended to 24 ft. (7.32 m) centerline to centerline, in their 1/2 extended position, or fully retracted for maximum flexibility. Easily removable 24" diameter Almag floats, each with an area of 452 in² (2919 cm²), stow on the outrigger boxes at their point of use. Complete controls and a sight leveling bubble are located in the operator's cab.

WHEELS AND TIRES

Disc type wheels with full tapered bead seat rim. 157.56" (4.0 m) wheelbase.

TIRES

Wide earthmover (E3) style tread tires provide life and flotation. 29.50x25, 28 P.R. - std.

SERVICE BRAKES

Split system air over hydraulic 18.5" (470 mm) diameter disc dual caliper brakes on all wheels.

PARKING BRAKE

Electrically controlled front axle mounted spring-set, air released drum type parking brake with indicator light.

OPTIONAL EQUIPMENT

Cold Weather Starting Aid, Immersion Heater, Pintle Hook, Clearance Lights, Front Mounted Winch - 20,000 lb (9 072 kg), Independent Rear or Four Mode Rear Wheel Steer.

ENGINE SPECIFICATION

Make and Model, Cummins QSB5.9 (275 hp)	
Type	6 cylinder
Bore and Stroke	4.02 x 4.72" (102 x 120 mm)
Displacement	359 in³ (5.9 L)
Rated HP	275 hp (205 kw) @ 2500 rpm
Max. Gross HP	275 hp (205 kw) @ 2300 rpm
Max. Gross Torque	750 lb • ft (990 N•m) @ 1500 rpm
Aspiration	Turbocharged & charge air cooled
Air filter	dry type
Electrical System	12 volt
Alternator	102 amp
Battery	(2) 12V-1900 C.C.A.
Fuel Capacity	80 gal (304 L)

All performance data is based on a gross vehicle weight of 94,898 lb (43 045 kg). 29.5x25 tires, 4x4 drive. Performance may vary due to engine performance. Gradeability data is theoretical and is limited by tire slip, machine stability, or oil pan design.

PERFORMANCE (STANDARD ENGINE)

Transmission Gear	Forward Drive	Max. Speed	Max. Tractive Effort	Gradeability @ Stall
1	4-wheel	2.1 mph (3.4 kph)	68,645 lb(31, 137 kg)	98.9%
2	4-wheel	4.4 mph (7.1 kph)	33,050 lb (14,991 kg)	34.8%
3	4-wheel	12.3 mph (19.8 kph)	11,7921b (5,349 kg)	10.5%
4	2-wheel	5.4 mph (8.4 kph)	27,7771b (12, 599 kg)	28.3%
5	2-wheel	10.9 mph (17.5 kph)	13, 3751b (6,067kg)	12.2%
6	2-wheel	25.0 mph (40.8 kph)	4,7681b (2,163 kg)	3%

HYDRAULIC SYSTEM

HYDRAULIC PUMPS

Three gear type pumps, one single and two in tandem, driven off the transmission. Combined system capability is 120 gpm (455 lpm). Includes pump disconnect on winch pump

Main and Auxiliary winch pump
- 57.8 gpm (218.8lpm) @ 4,500 psi (316.4 kg/cm²)

Boom Hoist and Telescope Pump
- 42.1 gpm (159.4 lpm) @ 4,500 psi (316.4 kg/cm²)

Power Steering, Outrigger and Swing Pump
- 20.2 gpm (76.5lpm) @ 3,500 psi (246.1 kg/cm2)

FILTRATION

Full flow oil filtration system with bypass protection includes a removable 60 mesh (250 micron) suction screen-type filter and five micron synthetic depth type media replaceable return line filter.

HYDRAULIC RESERVOIR

All steel, welded construction with internal baffles and diffuser.

Provides easy access to filters and is equipped with an external sight level gauge. The hydraulic tank is self pressurizing to aid in keeping out contaminants and in reducing potential pump cavitation. Capacity is 178 gal (674 liters). Hydraulic oil cooler is standard.

OPTIONAL HOIST LINE

Main winch and optional auxiliary winch 3/4" (19 mm) rotation resistant compacted strand 34 x 7 grade 1960. Min. breaking strength 34.5 tons (31.7 mt).

MAIN WINCH SPECIFICATIONS

Hydraulic winch with bent axis piston motor and planetary reduction gearing provides 2-speed operation with equal speeds for power up and down. Winch is equipped with an integral automatic brake, grooved drum, tapered flanges, standard cable roller on drum, and an electronic drum rotation indicator.

Performance	LO-Range	HI-Range
Max line speed (no load)		
First layer	191 fpm (9 m/min)	341 fpm (103.9 m/min.)
Fifth layer	275 fpm (83.8 m/min)	489 fpm (149.0 m/min.)
Max. line pull-first layer	18,450 lb (8 369 kg)	9,002 lb (4 083 kg)
Max. line pull-fifth layer	12,845 lb (5 826 kg)	5,052 lb (2 846 kg)
Permissible line pull	13,800 lb (6 260 kg)	

Drum Dimensions
- 13" (330 mm) drum diameter
- 20.16" (512 mm) length
- 12.5" (546 mm) flange dia.
- Cable: 3/4" x 600' (19 mm x 182.9 m)
- Cable type: 3/4" (19 mm) 6 x 19 IWRC XIPS, right regular lay, performed.
- Min. breaking strength 29.4 tons (26.6 mt)

Drum Capacity
- Max. Storage: 561' (171 m)
- Max. useable: 561' (171 m)*

*Based on minimum flange height above top layer to comply with ANSI B30.5

OPTIONAL AUXILIARY WINCH

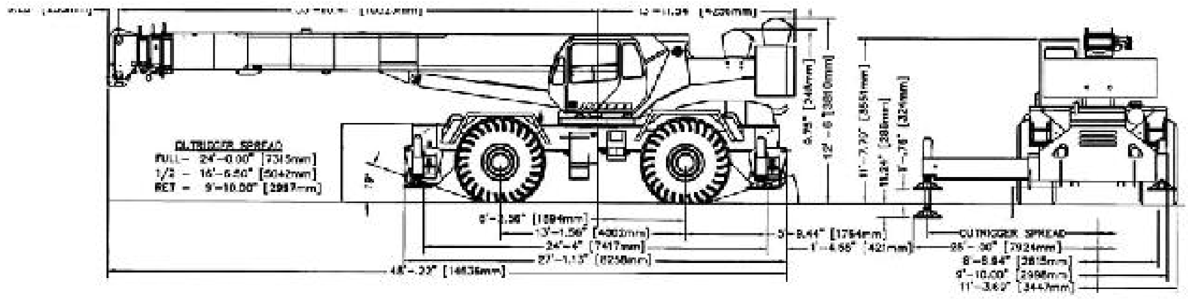
Hydraulic two-speed winch with bent axis piston motor, equal speed power up and down, planetary reduction with integral automatic brake, grooved drum with tapered flanges, drum roller, and rotation indicator.

Performance	
Max. line speed (no load) Fifth layer	489 fpm (149.0 m/min)
Max. line pull First layer	18,450 lb (8 369 kg)
Drum Dimensions and Capacity	(Same as main winch)

TEREX

GENERAL DIMENSIONS

1. Dimensions given assume the boom is fully retracted in travel position and 29.50 x 25 tires.
2. Minimum ground clearance under: transmission-29.00", axle bowls-23.62", tie rods-23.88"



WEIGHTS & AXLE LOADS	GROSS WEIGHT LB	UPPER FACING FRONT		GROSS WEIGHT KG	UPPER FACING FRONT	
		FRONT	REAR		FRONT	REAR
Basic Crane with 15,200 lb (6 895 kg) Counterweight	+ 91,216	+ 47,047	+ 44,169	+ 41,372	+ 21,338	+ 20,033
Add Options:						
32' (9.68 m) Swing-on jib (Stowed)	+ 1,270	+ 2,524	- 354	+ 576	+ 1,145	- 161
33'-57'(10.15-17.30 m)	+ 2,170	+ 3,992	- 1,822	+ 984	+ 1,811	- 826
Swing-on Jib (Stowed)						
Auxiliary Boom Head	+ 125	+ 406	- 281	+ 57	+ 184	- 127
Auxiliary Winch with 600' of 6x19 class Wire Rope	+ 134	- 35	+ 159	+ 61	- 16	+ 72
75T (68.0 mt) 5-Sheave Hook Block	+ 1,608	+ 3,447	- 1,839	+ 729	+ 1,563	- 834
60T (54.4 mt) 5-Sheave Hook Block	+ 1,204	+ 2,581	- 1,377	+ 546	+ 1,171	- 625
20T (18.1 mt) 1-Sheave Hook Block	+ 570	+ 936	- 366	+ 259	+ 425	- 166
12T (19.9 mt) Hook and Ball (In tool box)	+ 419	+ 426	- 7	+ 190	+ 193	- 3
Pintle Hook: Front:	+ 45	+ 60	- 15	+ 20	+ 27	- 7
Rear:	+ 45	- 25	+ 70	+ 20	- 11	+ 32
Substitute:						
600' of 34x7 class spin resistant wire rope	+ 96	- 30	+ 126	+ 44	- 14	+ 57

Note: Weights are for Terex supplied equipment and are subject to 2% variation due to manufacturing tolerances.

TEREX Cranes
106-12th Street S.E.
Waverly, Iowa 50677-9466 USA

TEL (319) 352-3920 FAX (319) 352-5727
EMAIL inquire@terexwaverly.com
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SECTION 9

SUBJECT **PAGE**

OSHA® FactSheet

Subpart CC – Cranes and Derricks in Construction: Wire Rope – Inspection

This fact sheet describes the inspection requirements of subpart CC – Cranes and Derricks in Construction, as specified in 29 CFR 1926.1413. These provisions are effective November 8, 2010. This document is intended to assist wire rope inspectors and supervisors.

Inspection Trigger	Inspection Details	Performed by	Documentation
Each shift	See list below, visual inspection must begin prior to each shift in which the equipment is used.	Competent Person	Not required
Monthly	See details below.	Competent Person	Required. Must be signed by the person who conducted the inspection and retained for a minimum of 3 months.
Annual	See details below.	Qualified Person	Required. Must be signed by the person who conducted the inspection and retained for a minimum of 12 months.

- The annual/comprehensive and monthly inspections must be documented according to 1926.1412(f)(7) and 1916.1412(e)(3), respectively.
- Rope lubricants of the type that hinder inspection must not be used.
- All documents produced under this section must be available, during the applicable document retention period, to all persons who conduct inspections under this section.

Shift Inspection

Shift inspections are visual inspections that a competent person must begin prior to each shift during which the equipment is used. Shift inspections do not require untwisting (opening) of wire ropes or booming down. The inspection must consist of observation of wire ropes (running and standing) that are likely to be in use during the shift for apparent deficiencies, including the following:

Apparent Deficiencies – Category I	Removal from Service Criteria
• Significant distortion of the wire rope structure such as kinking, crushing, unstranding, birdcaging, signs of core failure, or steel core protrusion between the outer strands. • Significant corrosion. • Electric arc damage (from a source other than power lines) or heat damage. • Improperly applied end connections. • Significantly corroded, cracked, bent, or worn end connections (such as from severe service).	If a Category I deficiency is identified, the competent person must immediately determine whether it constitutes a safety hazard. If the deficiency is determined to be a safety hazard, all operations involving use of the wire rope in question must be prohibited until: • The wire rope is replaced. (See 1926.1417), or • If the deficiency is localized, the problem is corrected by severing the wire rope in two; the undamaged portion may continue to be used. Joining lengths of wire rope by splicing is prohibited. If a rope is shortened under this paragraph, the employer must ensure that the drum will still have two wraps of wire when the load and/or boom is in its lowest position.

Apparent Deficiencies – Category II	Removal from Service Criteria
• Visible broken wires: ∘ In running wire ropes: six randomly distributed broken wires in one rope lay or three broken wires in one strand in one rope lay, where a rope lay is the length along the rope in which one strand makes a complete revolution around the rope. ∘ In rotation-resistant ropes: two randomly distributed broken wires in six rope diameters or four randomly distributed broken wires in 30 rope diameters. ∘ In pendants or standing wire ropes: more than two broken wires in one rope lay located in rope beyond end connections and/or more than one broken wire in a rope lay located at an end connection. • A diameter reduction of more than 5% from nominal diameter.	If a Category II deficiency is identified, operations involving use of the wire rope in question must be prohibited until: • Employer complies with the wire rope manufacturer's established criterion for removal from service, or with a different criterion that the wire rope manufacturer has approved in writing for that specific wire rope. (See 1926.1417). • The wire rope is replaced. (See 1926.1417), or • If the deficiency is localized, the problem is corrected by severing the wire rope in two; the undamaged portion may continue to be used. Joining lengths of wire rope by splicing is prohibited. If a rope is shortened under this paragraph, the employer must ensure that the drum will still have two wraps of wire when the load and/or boom is in its lowest position.

Apparent Deficiencies – Category III	Removal from Service Criteria
• In rotation-resistant wire rope, core protrusion or other distortion indicating core failure. • Prior electrical contact with a power line. • A broken strand.	If a Category III deficiency is identified, operations involving use of the wire rope in question must be prohibited until: • The wire rope is replaced. (See 1926.1417), or • If the deficiency (other than power line contact) is localized, the problem is corrected by severing the wire rope in two; the undamaged portion may continue to be used. Joining lengths of wire rope by splicing is prohibited. Repair of wire rope that contacted an energized power line is also prohibited. If a rope is shortened under this paragraph, the employer must ensure that the drum will still have two wraps of wire when the load and/or boom is in its lowest position.

Where a wire rope is required to be removed from service under this section, either the equipment (as a whole), or the hoist with that wire rope must be tagged-out, in accord with 1926.1417(f)(1), until the wire rope is repaired or replaced.

Critical Review Items

Particular attention must be given to all of the following:

- Rotation-resistant wire rope in use.
- Wire rope being used for boom hoists and luffing hoists, particularly at reverse bends.
- Wire rope at flange points, crossover points, and repetitive pickup points on drums.
- Wire rope at or near terminal ends.
- Wire rope in contact with saddles, equalizer sheaves or other sheaves where rope travel is limited.

Monthly Inspection

Each month an inspection must be conducted as stated under "Shift Inspection" above.

In addition to the criteria for shift inspection, monthly inspections require that:

- The inspection must include any deficiencies that the qualified person who conducts the annual inspection determines under 1926.1413(c)(3)(ii) must be monitored.
- Wire ropes on equipment must not be used until an inspection under this paragraph demonstrates that no corrective action under 1926.1413(a)(4) is required.
- The inspection must be documented according to 1926.1412(e)(3) (monthly inspection documentation).

Annual/Comprehensive Inspection

At least every 12 months, wire ropes in use on equipment must be inspected by a qualified person as stated under "Shift Inspection" above.

In addition to the criteria for shift inspection, annual inspections require that –

- The inspection must be complete and thorough, covering the surface of the entire length of the wire ropes, with particular attention given to all of the following:
  - Critical review items from 1926.1413(a)(3)–(see "Critical Review Items" above).
  - Those sections that are normally hidden during shift and monthly inspections.
  - Wire rope subject to reverse bends.
  - Wire rope passing over sheaves.

Exception

In the event an annual inspection under 1926.1413(c)(2) is not feasible due to existing set-up and configuration of the equipment (such as where an assist crane is needed) or due to site conditions (such as a dense urban setting), such inspections must be conducted as soon as it becomes feasible, but no longer than an additional 6 months for running ropes and, for standing ropes, at the time of disassembly.

- If a deficiency is determined to constitute a safety hazard, operations involving use of the wire rope in question must be prohibited until:
  - The wire rope is replaced (see 1926.1417), or
  - If the deficiency is localized, the problem is corrected by severing the wire rope in two; the undamaged portion may continue to be used. Joining wire rope by splicing is prohibited. If a rope is shortened under this paragraph, the employer must ensure that the drum will still have two wraps of wire when the load and/or boom is in its lowest position.
- If a deficiency is identified and the qualified person determines that, though not presently a safety hazard, the deficiency needs to be monitored, the employer must ensure that the deficiency is checked in the monthly inspections.

Additionally

- The inspection must be documented according to 1926.1412(f)(7).
- Rope lubricants of the type that hinder inspection must not be used.
- All documents produced under this section must be available, during the applicable document retention period, to all persons who conduct inspections under this section.

This is one in a series of informational fact sheets highlighting OSHA programs, policies or standards. It does not impose any new compliance requirements. For a comprehensive list of compliance requirements of OSHA standards or regulations, refer to Title 29 of the Code of Federal Regulations. This information will be made available to sensory-impaired individuals upon request. The voice phone is (202) 693-1999; teletypewriter (TTY) number: (877) 889-5627.

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WIRE ROPE USERS MANUAL

Fourth Edition

WIRE ROPE TECHNICAL BOARD

This publication is a cooperative effort of THE WIRE ROPE TECHNICAL BOARD and the companies which make up the wire rope manufacturing industry in the United States.

THE WIRE ROPE TECHNICAL BOARD (WRTB) is an association of engineers representing companies that account for more than 90 percent of the wire rope produced in the United States; it has the following objectives:

- To promote development of engineering and scientific knowledge relating to wire rope;
- To assist in establishing technological standards for military, governmental and industrial use;
- To promote development, acceptance and implementation of safety standards;
- To help extend the uses of wire rope by disseminating technical and engineering information to equipment manufacturers; and
- To conduct and/or underwrite research for the benefit of both industry and user.

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Contents

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Numerical and factual data, not otherwise credited, were obtained from published and unpublished sources supplied by the Wire Rope Technical Board (WRTB), and the companies which sponsor it.

ACKNOWLEDGEMENT

*The Wire Rope Technical Board expresses its appreciation to **Barney Bigler** for assistance to the WRTB Publications Committee in the publication of this Manual.*

1 Introduction

***ma•chine:** an assemblage of parts...that transmit forces, motion, and energy one to another in some predetermined manner and to some desired end...*

-Webster's Third New International Dictionary

In and of itself, wire rope is a machine. The geometry—or configuration— of its cross-section and the method and material of its manufacture are precisely designed to perform "in some predetermined manner and to some desired end." Hence, as befits any useful machine, it is imperative that the rope's potential use be fully recognized, that its functional characteristics be understood, and that procedures for proper maintenance be scrupulously adhered to. By giving active recognition to these generally accepted concerns, the user can be reasonably certain that maximum service life and safety will be realized for every rope installation or application.

A thorough understanding of wire rope characteristics is, of course, a primary essential. This means familiarity with operating conditions, design factors, rope grades and constructions. Full recognition of their inherent use-potential derives from a realization of the great number and wide variety of wire ropes available for general and special operating needs. It is of special importance that the user becomes familiar with the particular characteristics of the various constructions in order to make the right selection for a given function.

Fabricated to close tolerances, wire rope is inspected at all significant manufacturing intervals to assure the user of a uniformly high quality product. Immediately after manufacture, wire rope care becomes an absolute necessity. At no time can a proper regard for care and maintenance be neglected; this rule must be observed in handling, shipping, storage and installation procedures. Following this—after putting the rope in operation—approved maintenance practices and rigorous inspection (of both the rope and its associated equipment) must take place on a continuing basis. Only through strict adherence to these care and maintenance procedures can there be positive assurance that the rope will perform with optimal safety and efficiency throughout its entire life span.

This publication is the culmination of a joint effort by the wire rope industry. Its intended audience may be viewed, in broadest terms, as comprised of two sectors:

One of these—made up of those with a working knowledge of wire ropes—will find in these pages a comprehensive and convenient source of reference data from such areas as properties and characteristics, handling, storage, operation and maintenance—in short, a handy checklist.

For the second sector, the not as well informed or new user, this publication can serve as a broad-ranging introduction; for those readers, the information provided can help establish sound practices in rope selection and application. This means practices that are efficient and economical.

As a cooperative industry effort, this manual brings together a significant portion of the enormous collection of data now scattered about in the files and publications of many individual companies. The text offers many recommendations, both explicit and implied, but these have been made to provide some *initial* judgment points from which ultimate decisions as to design and use may be made.

The reader should consult with the wire rope manufacturer as to the specific application planned. The manufacturer's experience can then help the user make the most appropriate choice. **In the final analysis, responsibility for design and use decisions rests with the user.**

The selection of equipment or components is frequently influenced by the special demands of an industry. An equipment manufacturer may, for reasons of space, economy, etc., feel a need to depart from suggested procedures given in these pages. It is important to remember that such variations from recommended practices may be potential problem areas. However, when such circumstances are unavoidable they demand compensating efforts on the part of the user. These "extras" should include (but not necessarily be limited to) more frequent and more thorough inspections by skilled, specifically trained personnel. The inspection information included in this manual provides guidance and techniques to perform inspections of wire rope. Additionally, these circumstances may demand the keeping of special maintenance and lubrication records, and the issuance of special warnings regarding removal and replacement criteria.

2 Basic Components

Wire rope consists of three basic components; while few in number, these vary in both complexity and configuration to produce ropes for specific purposes or characteristics. The three basic components of a standard wire rope design are: 1) *wires* that form the strand, 2) *multi-wire strands* laid helically around a core, and 3) the *core* (Fig. 1).

Wire, for rope, is made in several materials and types; these include steel, iron, stainless steel, monel, and bronze. By far, the most widely used material is high-carbon steel. This is available in a variety of grades each of which has properties related to the basic curve for steel rope wire. Wire rope manufacturers select the wire type that is most appropriate for requirements of the finished product.

Grades of wire rope are referred to as traction steel (TS), extra high strength traction (EHS), improved plow steel (IPS), extra improved plow steel (EIPS), and extra extra improved plow steel (EEIPS). The plow steel strength curve forms the basis for calculating the strength of most steel rope wires in this manual; the tensile strength (psi) of any steel wire grade is not constant, it varies with the diameter and is highest in the smallest wires.

The most common finish for steel wire is "bright" or uncoated. Steel wires may also be metallic coated with zinc (galvanized) or zinc/aluminum alloy (mischmetal). "Drawn galvanized" wire has the same strength as bright wire, but wire "galvanized at finished size" is usually 10% lower in strength. For other applications, different coatings are available.

"Iron" type wire is actually drawn from low-carbon steel and has a fairly limited use except in elevator installations.

Stainless steel ropes, listed in order of frequency of use, are made of AISI types 302/304, 316, and 305. Contrary to general belief, hard-drawn stainless Type 302/304 *is* magnetic. Type 316 is less magnetic, and Type 305 has a permeability low enough to qualify as non-magnetic.

Monel metal wire is usually Type 400 and conforms to Federal Specification QQ-N-281.

Strands consist of two or more wires, laid in any one of many specific geometric arrangements, or in a combination of steel wires with some other materials such as natural or synthetic fibers. It is conceivable that a strand can be made up of any number of wires, or that a rope can have any number of strands. The following section, IDENTIFICATION and CONSTRUCTION, provides a complete description of most of the common wire rope constructions.

The *core* is the foundation of a wire rope; it is made of materials that will provide proper support for the strands under normal bending and loading conditions. Core materials include fibers (natural or synthetic) or steel. A steel core consists either of a strand or an independent wire rope. The three most commonly used

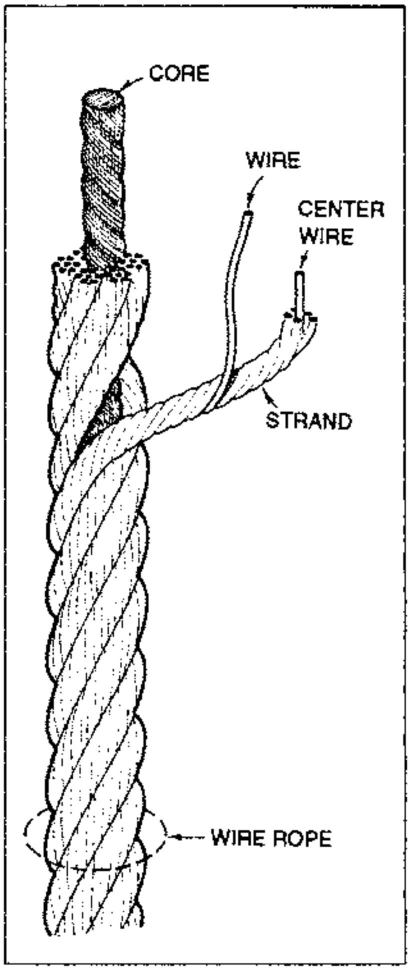


Figure 1. The three basic components of a typical wire rope.

core designations are: *fiber core* (FC), *independent wire rope core* (IWRC), and *wire strand core* (WSC) (Fig. 2). Catalog descriptions of the various available ropes always include these abbreviations to identify the core type. In selecting the most appropriate core for a given application, consult a wire rope manufacturer for guidance.

To summarize, *a wire rope consists, in most cases, of three components: wires, strands, and a core (Fig. 1). To these could be added other components such as lubricant and polymer. Lubricant is vital to the satisfactory performance of most wire ropes. Polymers are used either as a coating or filling of the wire rope or core to enhance performance in specific applications.*

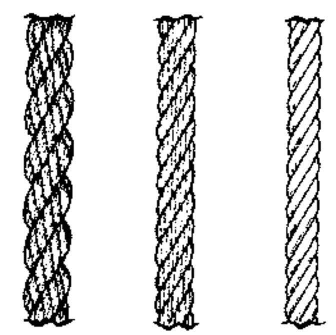


Figure 2. The three basic wire rope cores. In selecting the most appropriate core for a given application, a wire rope manufacturer should be called upon for guidance.

The core is the foundation of a wire rope. If the core cannot support the compressive load imposed, the rope will lose its clearance between strands and its service life will be shortened. Steel cores (WSC or IWRC) should be used when there is any evidence that a fiber core will not provide adequate support. Also, if the temperature of the environment may be expected to exceed 180° (82°C) steel cores must be used.

3 Identification and Construction

Wire rope is identified not only by its component parts, but also by its construction, i.e., by the way the wires have been laid to form strands, and by the way the strands have been laid around the core.

Figure 3, "a" and "c", show a right lay rope. Conversely, "b" and "d" show left lay rope.

Again in Figure 3, the first two illustrations ("a" and "b") show *regular lay* ropes. Following these are the types known as *lang lay* ropes ("c" and "d"). Note that the wires in regular lay ropes appear to line up with the axis of the rope; in lang lay ropes the wires form an angle with the axis of the rope. This difference in appearance is a result of variations in manufacturing techniques: regular lay ropes are made so that the direction of the wire lay in the strand is opposite to the direction of the strand lay in the rope; lang lay ropes are made with both strand lay and rope lay in the same direction. Finally, "e" called *alternate lay* consists of alternating right and left lay strands.

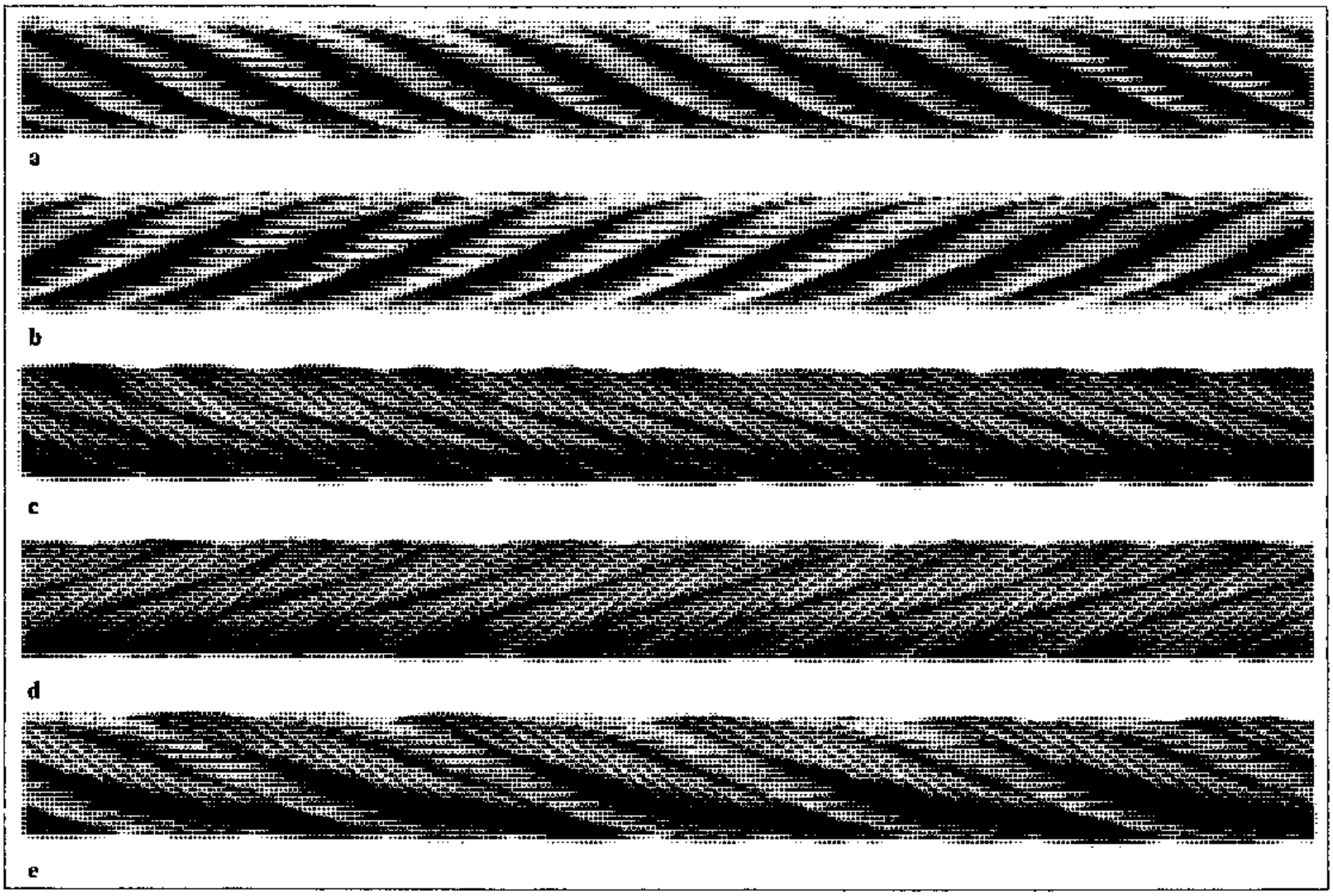


Figure 3. A comparison of typical wire rope lays: a) *right regular lay*, b) *left regular lay*, c) *right lang lay*, d) *left lang lay*, e) *right alternate lay*.

Of all the types of wire rope in current use, *right regular lay* (RRL) is found in the widest range of applications. Nonetheless, in many equipment applications *right lang lay* (RLL) or *left lang lay* (LLL) ropes are required. As for *alternate lay* (R-ALT or L-ALT) ropes, these are only used for special applications.

Compared to other types, the superiority of lang lay rope in certain applications derives from the fact that when bent over sheaves, its life span is longer than the others. Stated in another way, the advantage of lang lay rope is its greater fatigue resistance. Yet another claim is made for lang lay ropes: they are more resistant to abrasion.

It is important to understand the reasons for the advantages of lang lay rope. To begin with, consider its fatigue and bending properties. Figure 4A shows, in part, how the lang lay construction characteristics result in greater fatigue resistance than is found in regular lay rope. Note how the axis of the wire relates to the axis of the rope in both cases. When the regular lay rope is bent, the same degree of bend is imparted to the crowns of the outer wires.

Superior fatigue life in lang lay rope is also attributable to the longer exposed length of its outer wires. Note in Figure 4A, the valley-to-valley wire length in the laug lay rope is about 30% longer than in the regular lay rope. Bending the lang lay rope results in less axial bending of the outer wires. Lang lay rope displays 15 to 20% superiority over regular lay when bending is the principal factor affecting service life.

It is said that lang lay is more flexible, but flexibility should not be confused with fatigue resistance. These two attributes may, under certain circumstances, bear some relationship, but they are distinctly separate characteristics. *Flexibility* defines the relative ease with which a rope "flexes" or bends. *Fatigue resistance* defines the rope's ability to *endure* bending.

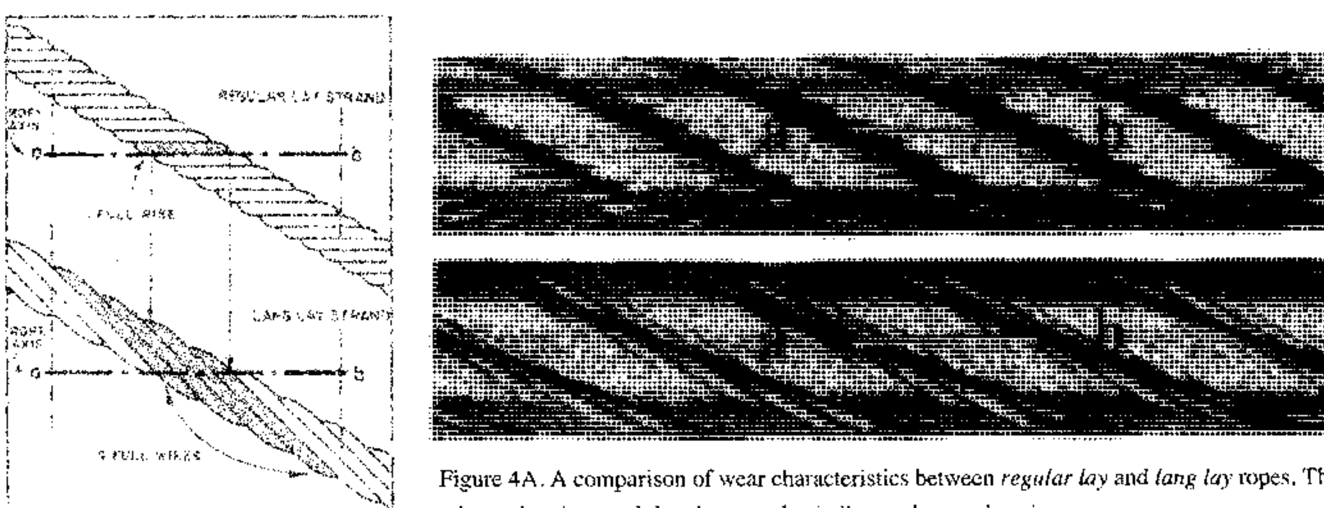


Figure 4A. A comparison of wear characteristics between *regular lay* and *lang lay* ropes. The lines a-b, on drawings and the photographs, indicates the rope's axis.

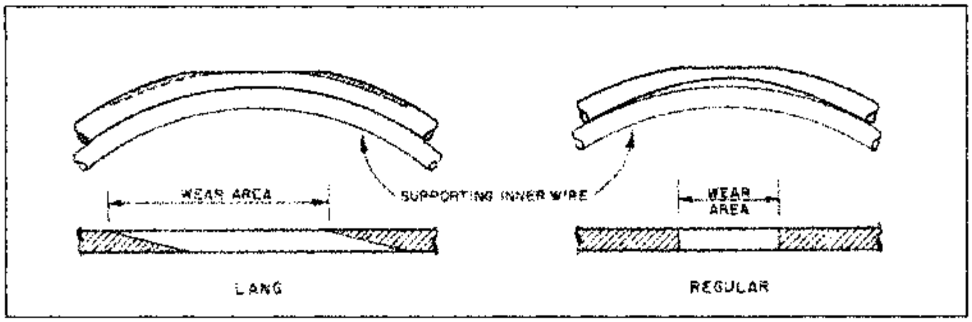


Figure 4B. The worn crown of the regular lay wire has a shorter exposed length.

Two other factors relate to fatigue; they are discussed here along with abrasion and peening characteristics.

The fact that the wires of regular lay rope are subject to higher unit pressure increases the rate of wear (abrasion and peening) of both wire and mating surface of the drum or sheave. Finally, the worn crown of the regular lay wire combined with its shorter exposed length, may allow the wire to spring away from the rope axis (Fig. 4B). Subsequent cycling on and off a sheave or drum can accelerate fatigue.

A note of caution: lang lay rope has some important limitations. First, if either end is not fixed, it will rotate severely when under load; and secondly, it is less able to withstand crushing action on a drum or sheave than is regular lay rope. Hence, lang lay rope should not be operated without being fixed so that neither end is free to rotate; nor should it be operated over minimum-sized sheaves or drums under extreme loads. Poor drum winding conditions are not well tolerated by lang lay ropes.

Preforming is a wire rope manufacturing process wherein the strands and their wires are formed during fabrication, to the helical shape that they will ultimately assume in the finished rope or strand.

The wire arrangement in the strands is an important determining factor in the rope's functional characteristics, i.e., its ability to meet the operating conditions to which it will be subjected. There are many basic strand patterns around which standard wire ropes are built; a number of these are illustrated in Figure 5.

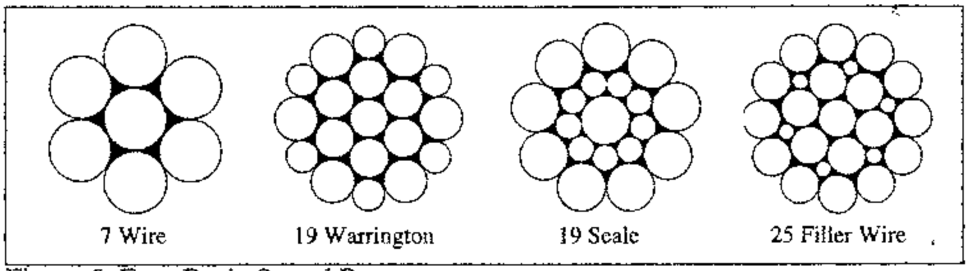


Figure 5. Four Basic Strand Patterns

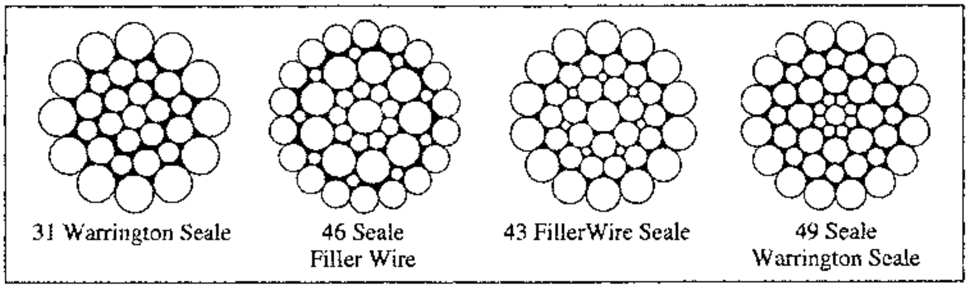


Figure 6. Combination Strand Patterns

The nomenclature used to identify a wire rope indicates: 1) the number of strands in the rope, 2) the number (nominal or exact) of wires in each strand, and 3) a descriptive word or letter indicating the type of construction, i.e., the geometric arrangement of wires.

Figure 5 shows cross sections of four basic strand constructions; Figure 6 shows several possible combinations of these constructions.

At this point, it would be useful to discuss wire rope nomenclature in detail because the subject may generate some misunderstanding. The reason for this stems from the practice of referring to rope either by classification or by its specific construction.

Rope classifications indicate the number of strands as well as the number of wires in each strand, e.g., 6 x 7, 6 x 19, 6 x 36, 8 x 19, 19 x 7, 35 x 7 etc. However, these are nominal classifications that may or may not reflect the actual construction. For example, the 6 x 19 classification includes constructions such as 6 x 21 Filler Wire, 6 x 25 Filler Wire, and 6 x 26 Warrington Seale. Despite the fact that none of the three constructions named have 19 wires, they are in the 6 x 19 classification.

As an example, a supplier receiving an order for 6 x 19 rope may assume this to refer to the classification, and could furnish any construction within this classification. But, if the job requires the special characteristics of a 6 x 26 Warrington Seale, and a 6 x 25 Filler Wire is supplied, shorter service life may result.

To avoid such misunderstandings, the safest procedure is to order a specific construction. In the event that the specific construction is not known or is in doubt, the rope should be ordered by classification along with a description of its end use.

Identification of wire rope in classifications facilitates selection on the basis of strength and weight/foot since it is customary practice that all similar ropes within a classification have the same minimum breaking force and approximate weight/foot.

Only three wire ropes under the 6 x 19 classification actually have 19 wires: 6 x 19 two-operation (2-op), 6 x 19 Seale (S), and 6 x 19 Warrington (W). All the rest have different wire counts. In the 6 x 36 (previously 6x37 and changed to conform with international standards) classification, there is a greater variety of wire constructions. The commonly available constructions in the 6 x 36 classification include: 6 x 31 Warrington Seale (WS), 6 x 36 WS, 6 x 41 Seale Filler Wire (SFW), 6 x 41 WS, 6 x 43 Filler Wire Seale (FWS), 6 x 49 Seale Warrington Seale (SWS), etc. For the users' convenience, Table 1 lists the most widely used rope classifications.

While the interior of a strand is of some significance, its important characteristics relate to the number and size of the outer wires. This is discussed in detail in the section titled **FACTORS AFFECTING THE SELECTION OF WIRE ROPE** (p. 59).

Wire rope nomenclature also defines the following:

Rope Description

- length
- size (nominal diameter)
- Preformed or non-preformed
- direction and type of lay
- finish of wires
- grade of rope
- type of core

If direction aud type of lay are omitted from the rope description, it is presumed to be right regular lay. Two other assumptions are made by the supplier: 1) if finish of wire is omitted, this will be presumed to mean uncoated "bright" finish, and 2) if no mention is made with refereuce to preforming, preforming will be presumed. (Note that an order for elevator rope must have an explicit statement since both preformed and non-preformed ropes are used extensively.)

As an example, a complete description would appear thus:

600 ft 3/4" 6 x 25 FW preformed RRL
Extra Improved Plow Steel IWRC

When a center wire is replaced by a strand, it is considered as a single wire, and the rope classification remains unchanged.

The wire rope cross sections illustrated in Figures 7 and 8 represent some of the most commonly used configurations, and are arranged under their respective classifications. Since these are in greater demand, they are more generally available.

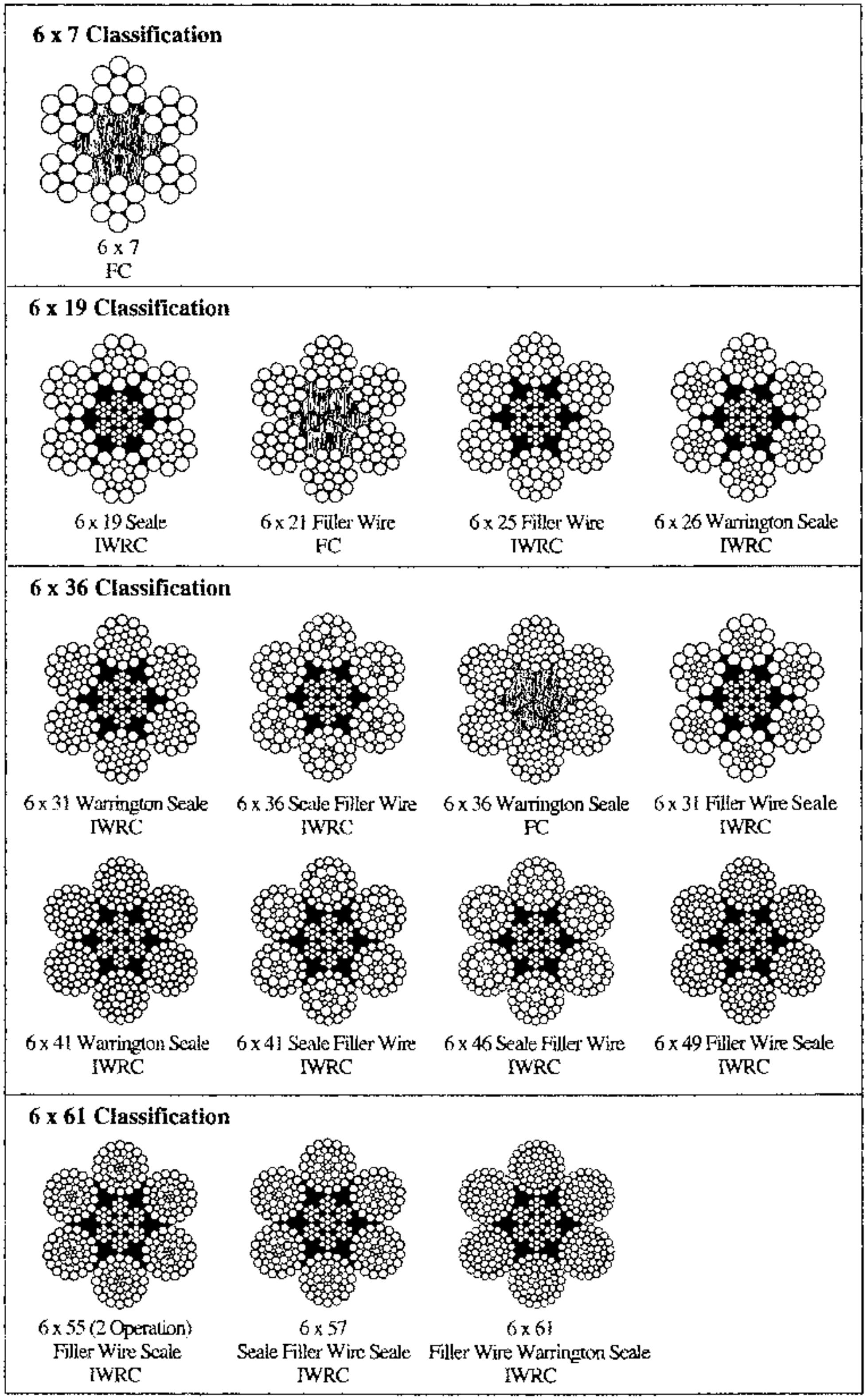
TABLE 1 WIRE ROPE CLASSIFICATIONS
Based on the Nominal Number of Wires in Each Strand

Classification	Outer Strands	Wires/Strand	MaximumNo. Outer Wires
6x7	6	3-14	9
6x19	6	15-26	12
6x36	6	27-49	18
6x61	6	50-74	24
6x91	6	75-109	30
7x19	7	15-26	12
7x36	7	27-49	18
8x7	8	3-14	9
8x19	8	15-26	12
8x36	8	27-49	18
8x61	8	50-74	24

Rotation Resistant Rope:

Classification	Total Strands	Wires/Strands	MaximumNo. Outer Wires
8x19	15	15-26	12
19x7	17-19	6-9	8
19x19	17-19	15-26	12
35x7	26-36	6-9	8
35x19	26-36	15-26	12

Figure 7. Cross sections of some commonly used wire rope constructions.



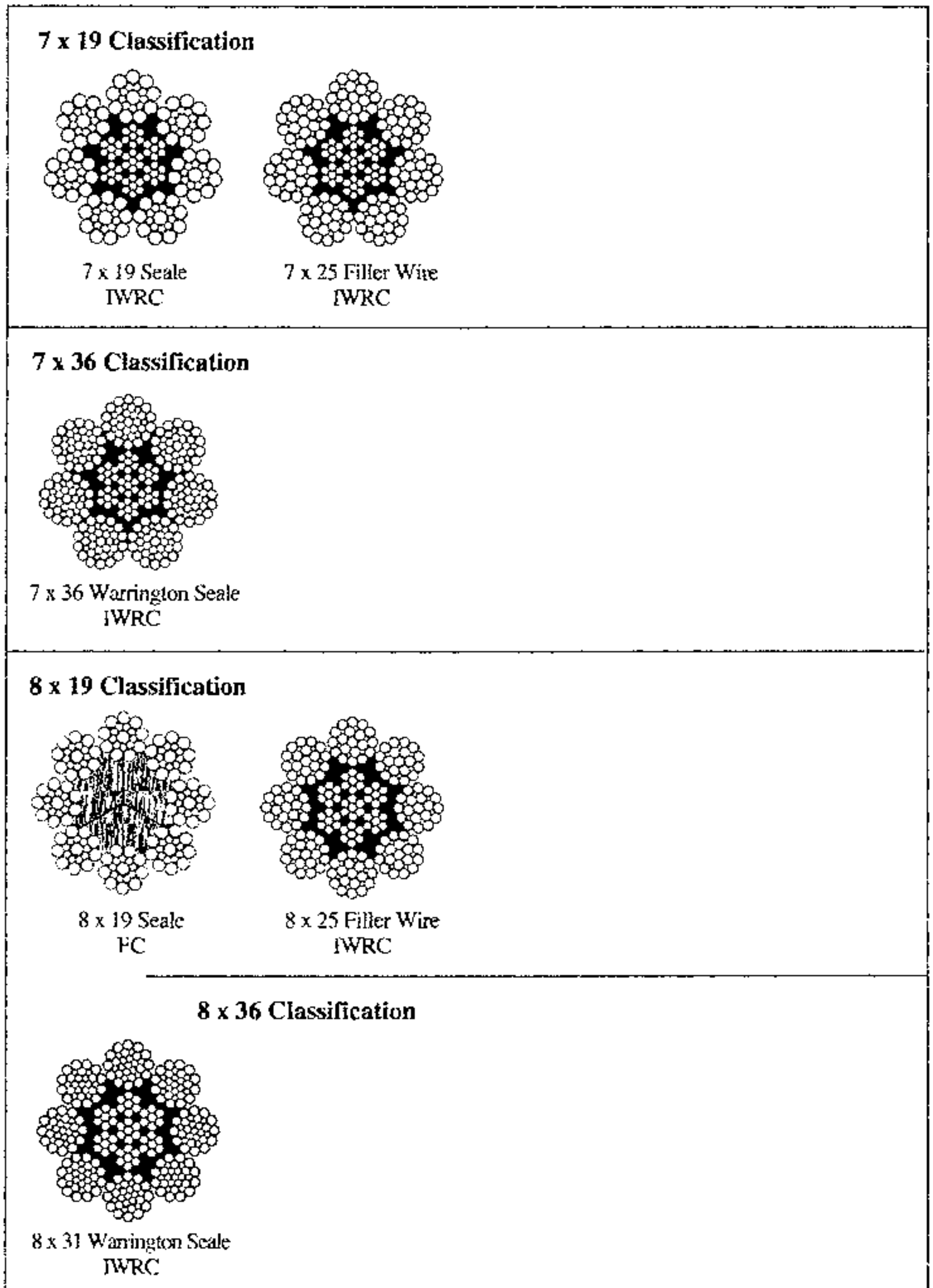


Figure 8. Cross sections of some commonly available wire rope constructions.

SPECIAL CONSTRUCTIONS

Many wire rope designs have been developed by the wire rope industry for use on applications requiring special wire ropes. Within the scope of this publication, it would not be feasible either to list or describe all the possible rope design variations. The following section describes some of the more popular special constructions. Information is provided about the construction and mechanical features of these ropes to assist the user.

ROTATION RESISTANT ROPES

Rotation Resistant ropes are designed to resist the tendency to spin or rotate under load. These ropes are used either as single part lines or in situations where operating conditions require a rope that will resist block rotation in a multipart system. The essential nature of rotation resistant rope designs impose certain limitations on their application and necessitate special handling requirements not encountered with other rope constructions.

There are three categories of Rotation Resistant ropes. They are defined as follows:

Category 1. Stranded rope constructed in such a manner that it displays little or no tendency to rotate, or if guided, transmits little or no torque, has at least fifteen outer strands and comprises an assembly of at least three layers of strands laid helically over a center in two operations, the direction of lay of the outer strands being opposite to that of the underlying layer.

Category 2. Stranded rope constructed in such a manner that it has significant resistance to rotation, has at least ten outer strands, and comprises an assembly of two or more layers of strands laid helically over a center in two or three operations, the direction of lay of the outer strands being opposite to that of the underlying layer.

Category 3. Stranded rope constructed in such a manner that it has limited resistance to rotation, has no more than nine outer strands, and comprises an assembly of two layers of strands laid helically over a center in two operations, the direction of lay of the outer strands being opposite to that of the underlying layer.

ISO 21669 specifies a method for determining the rotational properties of wire rope and guidance for use with a swivel based on this value.

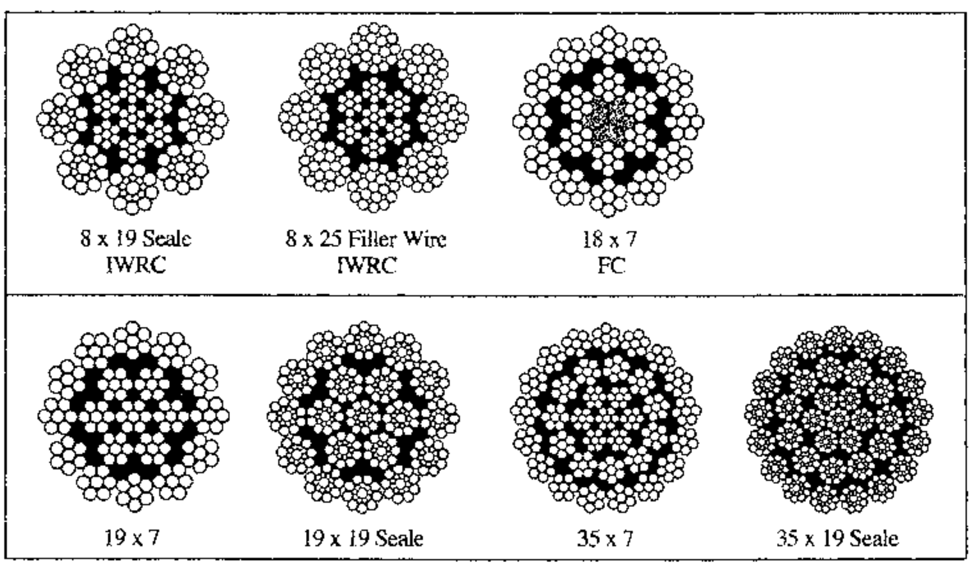


Figure 9. Cross sections of rotation resistant rope constructions.

Ropes having three or four strands can also be designed to have rotation resistant properties.

In Rotation Resistant ropes, the crossover points between strand layers are points of high stress concentration. Relative motion of the strands at these points results in accelerated deterioration of the internal components of the rope. Because of this characteristic of Rotation Resistant construction, care must be taken to avoid high loads with small diameter sheaves. Design factors less than 5 are not recommended except for Category 1 Rotation Resistant ropes that can be used at a design factor of 4.5. Sheave diameter (D/d ratios) recommendations are found in Section 5 of this manual.

A primary feature which distinguishes the various Rotation Resistant constructions is rotation under load. Figure 10 illustrates this property for various types of rotation resistant ropes, as compared to 6 x 25FW IWRC.

In addition to rotation, other characteristics of the rope must be considered in making a proper rope selection. See "Factors Affecting the Selection of Wire Rope" in Section 5.

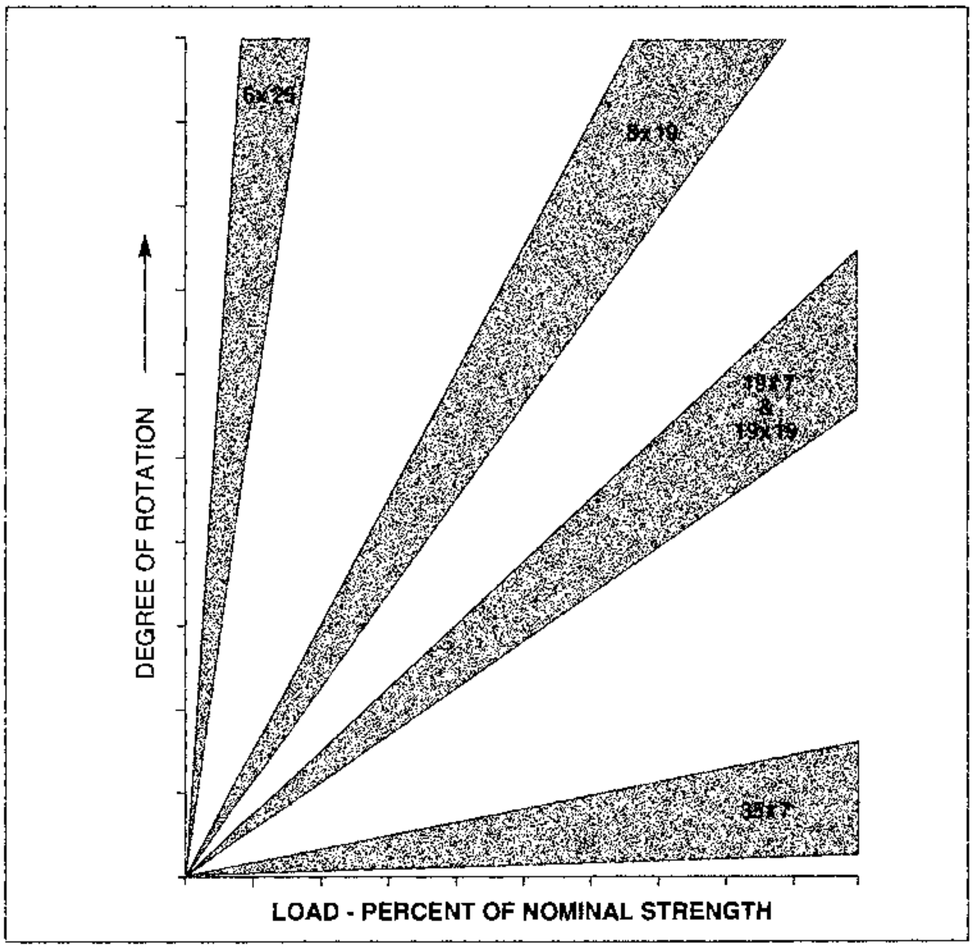


Figure 10. Relative rotation with one end allowed to rotate freely.

SPECIAL RECOMMENDATIONS FOR ROTATION RESISTANT ROPES

Many Rotation Resistant ropes are partially preformed and some are non-preformed. Ends of the rope should be seized tightly, welded or brazed, to prevent lay disturbances of the outer strands or core (two or three seizings are recommended). Care must be taken to avoid inducing twist into the rope during handling and installation.

GUIDELINES FOR THE INSTALLATION OF ROTATION RESISTANT ROPE:

• Follow instructions for removing rope from a reel or coil in Section 4.

• Use a pulling grip fitted with a swivel when pulling new rope through the reeving system with a used rope. This practice will prevent residual twist in the pulling rope from being transferred to the new rope. The pulling rope should be the same lay direction as the rope being installed. Except for Rotation Resistant ropes that are lang lay, lang lay ropes should not be used as pulling ropes.

• Apply back tension to the payoff reel during installation or tension the rope after installation and before being put into service. This will promote uniform spooling and help prevent rope pull-in. Recommended tension values range from 2% to 5% of the minimum breaking force of the rope being installed.

• Operate the new rope through several complete cycles at progressively higher loads. This will allow the rope to adjust gradually to operating conditions.

The proper operation of Rotation Resistant ropes depends on maintaining the torsional balance of the rope during use. Imbalance between inner and outer layers of the rope can be caused by twist induced in the rope as a result of incorrect installation procedures or undesirable operating conditions. Common causes of twist are improper fleet angles (Figure 39), improper sheave alignment, or poor spooling. Odd part reeving with off center attachment of the dead end to the block or improper reeving can cause misalignment of the traveling block inducing twist into the rope.

Although these ropes are classified as Rotation Resistant it must be realized that some slight rotation may occur, particularly in the early stages of rope life. This rotation may result in undesirable block rotation or "cabling", in multipart systems, or rotation of the load in single part. If this occurs, it is advisable to relieve the twist by disconnecting the most accessible end of the rope, letting the twist out of the rope and then reconnecting it. In some applications, swivels are used to relieve accumulated rope twist during installation and periodically during operation. When using Category 2 or 3 Rotation Resistant ropes, the swivel should be locked off after twist is relieved to prevent uncontrolled rotation. Most Category 1 ropes may be used with a swivel. Consult the rope manufacturer for guidance on any specific rope construction.

ELEVATOR ROPE

CONSTRUCTIONS

Wire ropes used in elevators (the term "lift" is used internationally) are designed and manufactured specifically for that application and are not interchangeable with standard wire ropes. The most common elevator rope constructions are shown in Figure 11. Many factors determine selection of a rope construction to perform one of the functions in the elevator system. It is best to follow the recommendation of the elevator manufacturer when replacing rope. In fact, replacement of ropes must conform to rules specified in ASME A17, Safety Code for Elevators and Escalators.

Almost all rope furnished for elevator service contains a core developed specifically for this application. Rope with an independent wire rope core (IWRC) is used in some applications.

Elevator rope is furnished primarily in right regular lay and right lang lay.

GRADES

Elevator rope is produced in three basic grades:

Traction - the most common grade of elevator rope, is primarily used for hoist ropes which require a blend of ductility and strength.

Extra High Strength Traction -primarily used where high speed or great height require a higher nominal breaking strength hoist rope. It may also perform better in more abrasive undercut-U and V-type groove applications.

Iron - primarily used for elevator applications other than hoist rope.

For information on minimum breaking force see Tables 41 and 42.

As noted, it is beyond the scope of this publication to discuss design and selection considerations for elevator rope. Information concerning sheave diameters, design factors (ratio of minimum breaking force to working load), groove contours, socketing and inspection, can be found in the ASME A17 code.

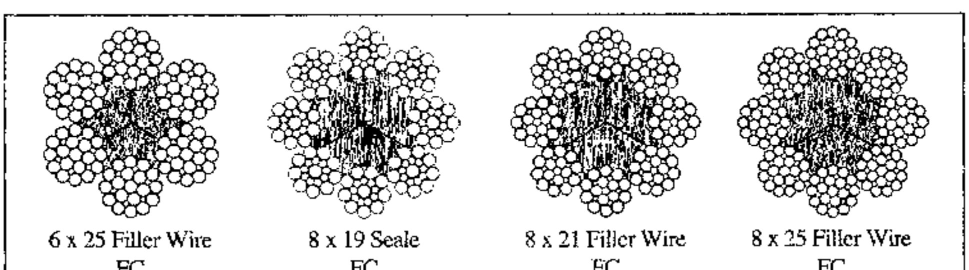
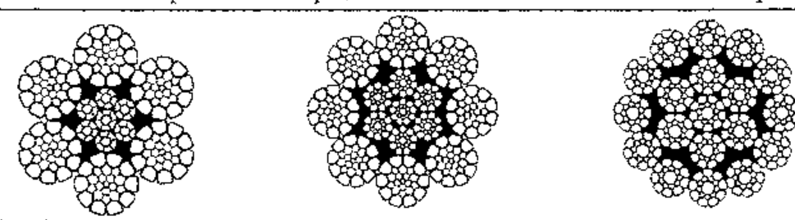


Figure 11
Common Elevator Rope Constructions

COMPACTED STRAND WIRE ROPE

Compacted strand wire rope is a wire rope manufactured from strands which have been compacted or reduced in diameter either in the stranding operation or in a separate operation after stranding prior to closing of the rope. There are various known methods for compacting; drawing the strand through a compacting die, roller reduction and rotary swaging are several examples. The compacting process flattens the surface of the outer wires and reforms internal wires of the strand to increase the density of the strand. The result is a smoother bearing surface at the strand crowns and an increase in minimum breaking force over round strand rope of the same diameter and classification. Cross section diagrams of rope with compacted strands are found in Figure 12.

Tables 37, 38 & 39 show compacted strand rope minimum breaking forces commonly available in 6 strand rope, 19 strand rotation resistant rope and 35 strand rotation resistant rope. For information on the exact minimum breaking force available on a particular rope, consult the manufacturer of the rope.

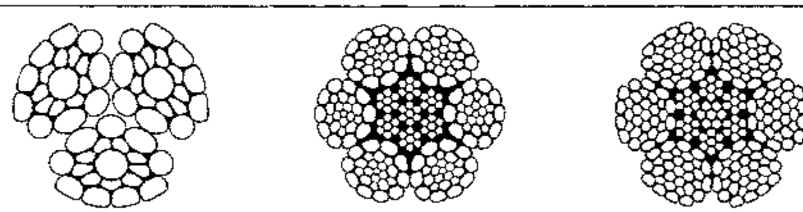


6 x 26 Warrington Seale Compacted Strand IWRC | 8 x 26 Warrington Seale Compacted Strand IWRC | 19 x 19 Seale Compacted Strand

Figure 12. Compacted Strand Wire Rope Cross Sections.

COMPACTED (SWAGED) WIRE ROPE

A compacted (swaged) wire rope is compacted or reduced in diameter in a separate operation following closing of the rope. A compacted wire rope can be made with non-compacted strands or compacted strands. Rotary swaging is the most common process to compact the rope, although other processes may be used. As illustrated in Figure 13, the wires and strands of the rope are flattened to produce a relatively smooth and wear resistant outer surface. Compacted ropes generally have good wear resistance, crushing resistance and high strength. However, compacted (swaged) wire rope may not have bending fatigue resistance that is equivalent to standard or compacted strand wire ropes, especially at small bending ratios. Minimum breaking forces for some compacted rope are found in Table 42.

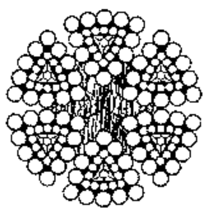


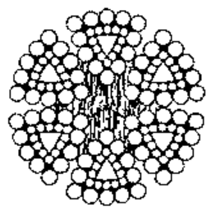
3 x 19 Seale Compacted (Swaged) | 6 x 26 Warrington Seale Compacted (Swaged) IWRC | 6 x 31 Warrington Seale Compacted (Swaged) IWRC

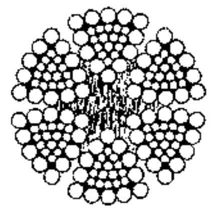
Figure 13. Compacted Wire Rope cross sections.

FLATTENED (TRIANGULAR) STRAND WIRE ROPE

Each strand of a flattened strand wire rope is comprised of a layer or layers of wire around a triangular shaped center. The center consists of either a triangular shaped wire element, or wires in a triangular configuration. The triangular strand shape provides a high strength rope with high metallic area which is resistant to crushing. Abrasion resistance is enhanced by an increased bearing surface, in comparison to round strand ropes. Various flattened strand constructions are illustrated in Figure 14. Minimum breaking forces for flattened strand ropes are found in Tables 29 and 30.


6 x 31 Style V Flattened Strand (Brangle Center) FC


6 x 25 Style B Flattened Strand (Solid Center Wire) FC


6 x 27 Style H Flattened Strand (3 Wire Center) FC

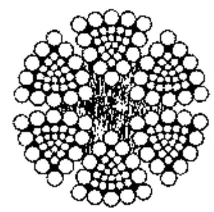

6 x 30 Style G Flattened Strand (Plaited Center) FC

Figure 14. Flattened Strand Wire Rope Cross Sections.

PLASTIC COATED WIRE ROPE

Various wire rope constructions are available with a plastic coating applied to the exterior of the rope. Small diameter galvanized and stainless steel wire ropes with plastic coating are common. The plastic coating can provide protection against corrosion and in some cases reduce wear of the rope and other rigging components. Plastic coated ropes can be difficult to inspect. Minimum breaking forces for plastic coated ropes are based on the diameter and grade of the rope prior to coating.

Plastic coated wire ropes are typically not used as operating ropes, but mostly as standing or stationary ropes. There are exceptions such as can conveyor ropes, some aircraft cables and other small diameter ropes.

PLASTIC FILLED WIRE ROPE

Plastic filled wire ropes are wire ropes in which internal spaces are filled with a matrix of plastic. The plastic extends to, or slightly beyond, the outer circumference of the rope. Plastic filling may improve bending fatigue life by reducing internal and external wear. Minimum breaking forces for plastic filled ropes are based on the diameter and grade of the rope prior to plastic filling.

Plastic filled wire ropes are used in many demanding applications and require special handling and inspection techniques. Consult the rope manufacturer for specific instructions and recommendations. The Inspection section of this manual provides detail on inspection of plastic filled ropes.

PLASTIC COATED OR PLASTIC FILLED IWRC WIRE ROPE

Plastic coated IWRC wire rope is wire rope which incorporates a plastic coated or plastic filled IWRC. The plastic coated or plastic filled IWRC reduces internal wear and may increase bending fatigue life. Minimum breaking forces for plastic coated and plastic filled ropes are based on the diameter and grade of the rope with an uncoated or unfilled IWRC.

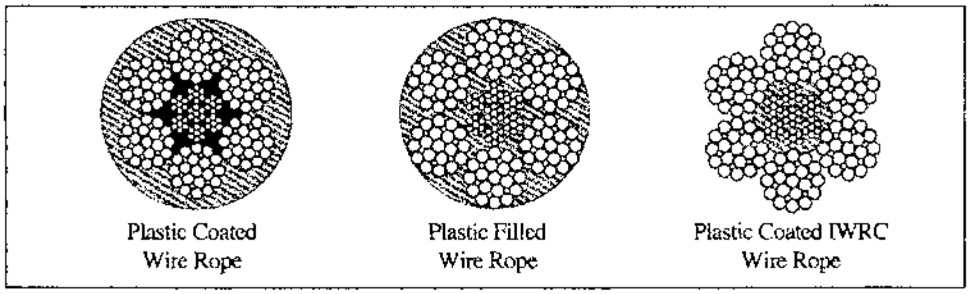


Figure 15. Plastic Processed Wire Rope Cross Sections.

OTHER SPECIAL CONSTRUCTIONS

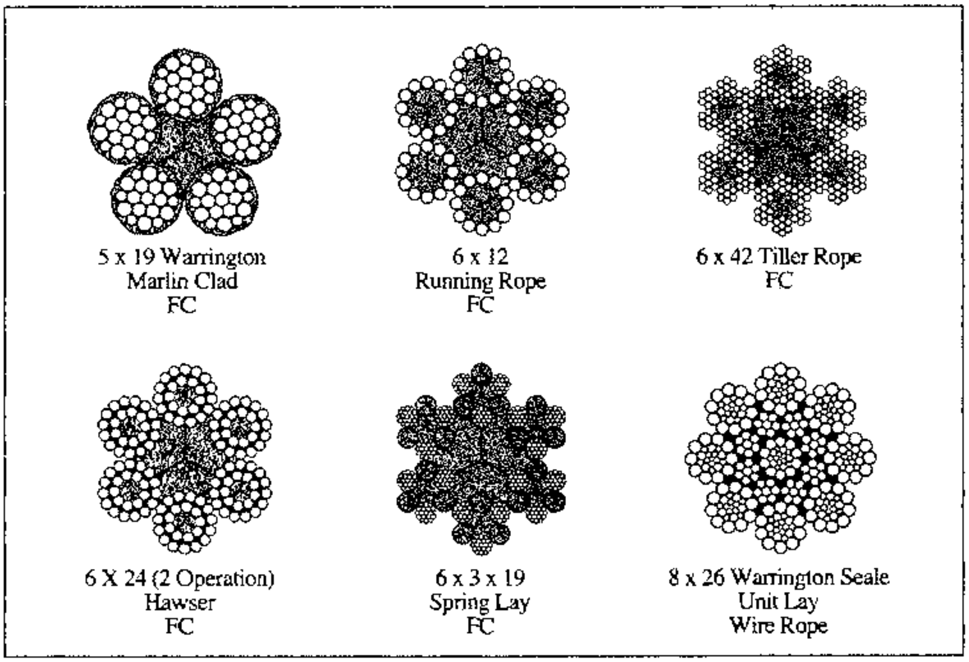


Figure 16. Some special purpose constructions.

TABLE 2 SPECIAL CONSTRUCTIONS

3 x 7	Guard Rail Rope
3 x 19	Slusher
6 x 12	Running Rope
6 x 24	Hawsers
6 x 30	Hawsers
6 x 42	(6 x 6 x 7) Tiller Rope
6 x 3 x 19	Spring Lay
5 x 19	Marlin Clad
6 x 19	Marlin Clad
Unit Lay (Parallel Lay)	

4 Handling and Installation

RECEIVING, INSPECTION, AND STORAGE

For all wire rope, the best time to begin taking appropriate care and handling measures is immediately upon receiving it. On arrival, the rope should be carefully checked to make certain that the delivered product matches the description on tags, requisition forms, packing slips, purchase order, and invoice.

After these necessary preliminary checks, the next concern is that of providing weather-proof storage space. If wire rope is to be kept unused for a considerable time, it must be protected from the elements. The ideal storage area is a dry, well-ventilated building or shed. Avoid closed, unheated, tightly sealed buildings or enclosures because condensation will form when warm, moist outside (ambient) air envelops the colder rope. Although wire rope is protected by a lubricant, this is not totally effective since condensation can still occur within the small interstices between strands and wires, thereby causing corrosion problems.

On the other hand, if the delivery site conditions preclude storage in an inside space and the rope must be kept outdoors, it should be covered with a waterproof material. This covering will also prevent the lubricant from drying out. Store the reel on an elevated platform or pallet that will keep it from direct contact with the ground.

Never store wire rope in areas subject to elevated temperatures. Dust and grit, or chemically laden atmospheres should also be avoided. Although lubricant applied during manufacturing offers initial protection, extended storage may require additional field lubrication.

Whenever wire rope remains on an idle machine, coat the rope with an appropriate protective lubricant. This will provide additional protection against environmental conditions. If the wire rope is inactive for an extended period while wound on the drum of the idle equipment, it may be necessary to apply a coating of lubricant to each layer as the rope is wound on the drum. Cleaning, inspection and re-lubrication should precede start-up of the equipment.

WIRE ROPE INSTALLATION

CHECKING THE DIAMETER

It is important to check the diameter of the delivered rope *before* installation. This is to make certain that the rope meets the specified nominal diameter for the given application.

Imperial (inch) and metric (millimeter) ropes are not always interchangeable. Consult the rope manufacturer for details on any specific rope diameter.

The actual rope diameter is the diameter of the circumscribing circle, i.e., its largest cross-sectional dimension. To insure accuracy this measurement should be made with a wire rope caliper using the *correct* method (b) shown in Fig. 17. Special techniques and equipment must be employed for measuring ropes with an odd number of outer strands (e.g. Circumferential tapes, calipers and plates).

Tolerance for wire rope diameter permit the diameter to be slightly larger than the nominal size, according to the limits shown in Table 3.

TABLE 3 OVERSIZE LIMITS OF WIRE ROPE DIAMETERS*

Nominal Rope Diameter	Allowable Limits	
Thru 1/8" (3.2 mm)	- 0	+8%
Over 1/8" (3.2 mm) thru 3/16" (4.8 mm)	- 0	+7%
Over 3/16" (4.8mm) thru 5/16" (8.0 mm)	- 0	+6%
Over 5/16" (8.0mm) and larger	-0	+5%

* These limits have been adopted by the Wire Rope Technical Board (WRTB). In the case of certain special purpose ropes, such as aircraft cables and elevator ropes, each has specific requirements. If a question should arise regarding compliance with oversize tolerances the rope may be measured under tension not exceeding 20% of the minimum breaking force. If the actual diameter determined by this measurement is within the specified tolerance the rope is considered to meet the required diameter.

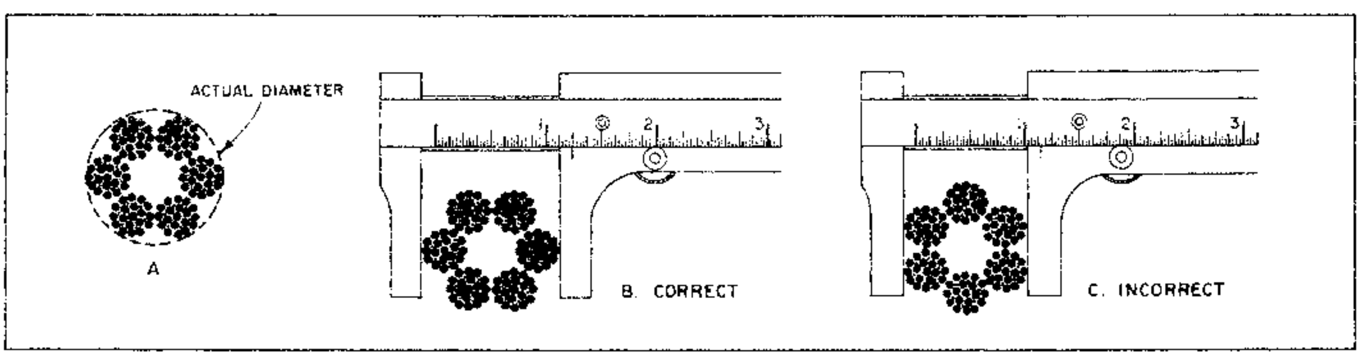


Figure 17. How to measure (or caliper) a wire rope correctly. Since the "true" diameter (A) lies within the circumscribed circle, always measure the larger dimension (B).

UNREELING AND UNCOILING

Wire rope is shipped in cut lengths, either in coils or on reels. Great care should be taken when the rope is removed from the shipping package since it can be permanently damaged by improper unreeling or uncoiling. Looping the rope over the head of the reel or pulling the rope off a coil while it is lying on the ground, will create loops in the line. Pulling on a loop will, at the very least, produce imbalance in the rope and may result in open or closed kinks (Fig. 18). Once a rope is kinked, the damage is not repairable. The kink must be cut out or the rope is unfit for service.

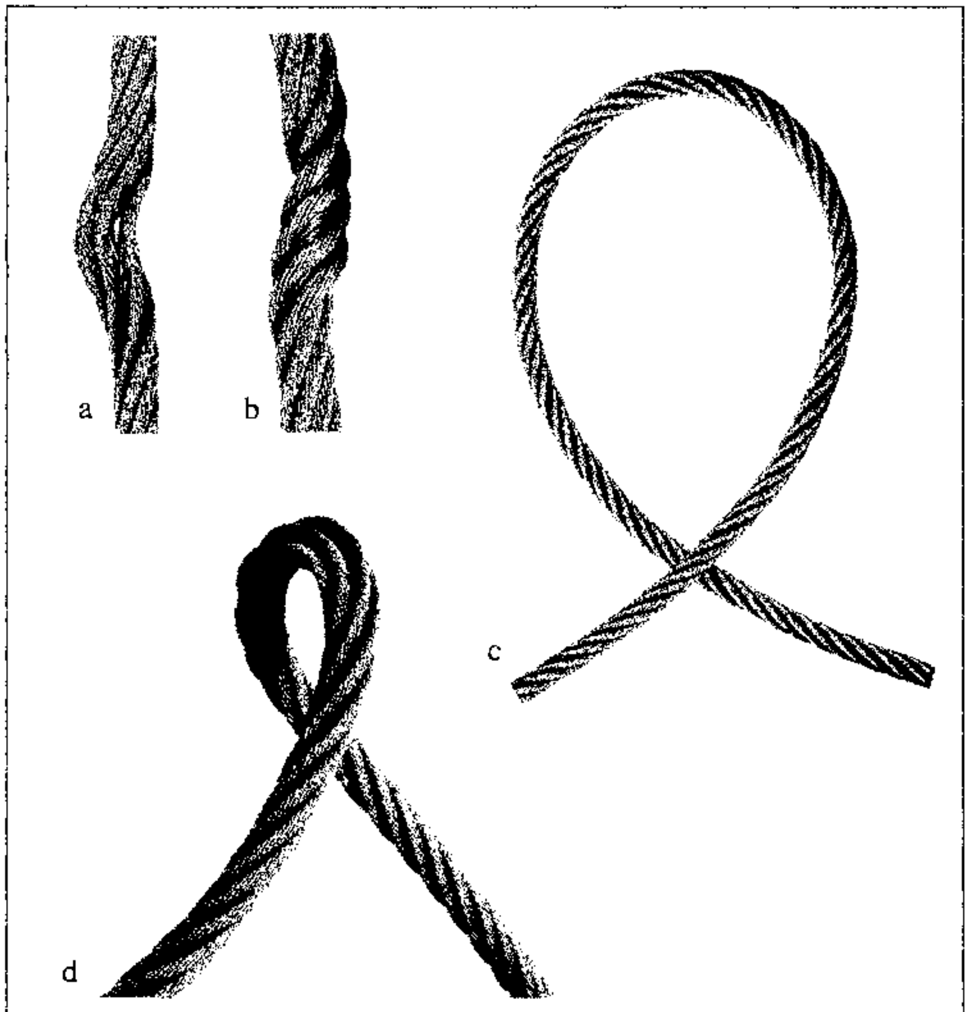


Figure 18. Improper handling can create *open* (a) or *closed kinks* (b). The open kink will open the rope lay; the closed kink will close it.

Starting loop (c): Do not allow the rope to form a loop. If, however, a loop does form and is removed at the stage shown, a kink can be avoided.

Kink (d): In this case, the looped rope was put under tension, the kink was formed, the rope is permanently damaged.

Unwinding wire rope from its reel also requires careful and proper procedure. There are three methods to perform this step correctly:

1) The reel is mounted on a shaft supported by two jacks or a roller payoff (Fig. 19). Since the reel is free to rotate, the rope is pulled from the reel by a workman holding the rope end, and walking away from the reel as it unwinds. A braking device should be employed so that the rope is kept taut and the reel is restrained from over-running the rope. This is necessary particularly with powered de-reeling equipment.
2) Another method involves mounting the reel on an unreeling stand (Fig. 20). It is then unwound in the same manner as described above (1). In this case, however, greater care must be exercised to keep the rope under tension sufficient to prevent the accumulation of slack. Slack can allow the rope to drop below the lower reel head and be damaged or loose wraps on the reel to fall over the rope coming off the reel and become tangled.
3) In another accepted method, the end of the rope is held while the reel itself is rolled along the ground. With this procedure, the rope will pay off properly however, the end being held will travel in the direction the reel is being rolled. As the difference between the diameter of the reel head and the diameter of the wound rope increases, the speed of travel will increase.

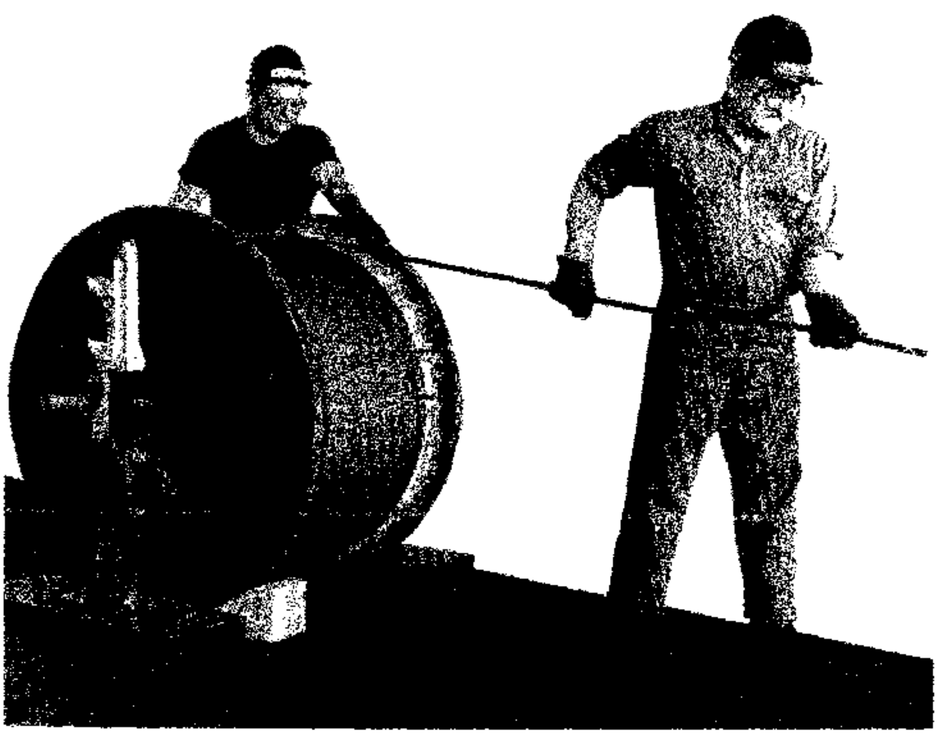


Figure 19. The wire rope reel is mounted on a shaft supported by jacks. This permits the reel to rotate freely, and the rope can be unwound either manually or by a powered mechanism.

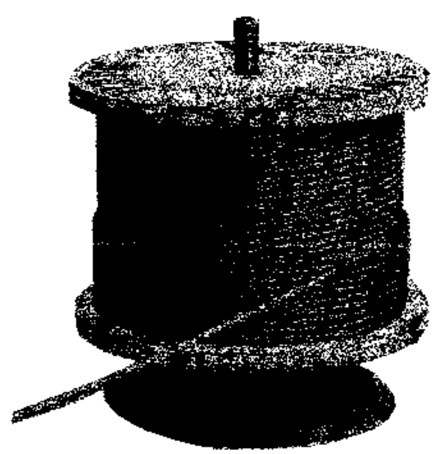


Figure 20. A vertical unreeling stand.

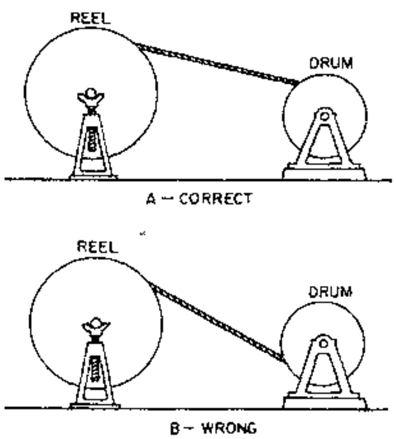


Figure 21. The correct (a) and the wrong (b) way to wind wire rope from reel to drum.

When re-reeling wire rope from a horizontally supported reel to a drum it is preferable for the rope to travel from the top of the reel to the top of the drum; or, from the bottom of the reel to the bottom of the drum (Fig. 21). Re-reeling in this manner will avoid putting a reverse bend into the rope during installation. If a rope is installed so that a reverse bend is induced, it may cause the rope to become "twisty" and, consequently, harder to handle.

When unwinding wire rope from a coil, there are two suggested methods for carrying out this procedure in a proper manner:

1) One method involves placing the coil on a vertical unreeling stand. The stand consists of a base with a fixed vertical shaft. On this shaft there is a "swift," consisting of a plate with inclined pins positioned so that the coil may be placed over them. The whole swift and coil then rotate as the rope is pulled off. This method is particularly effective when the rope is to be wound on a drum.
2) The most common as well as the easiest uncoiling method is merely to hold one end of the rope while rolling the coil along the ground like a hoop (Fig. 22).

Figures 23 and 24 show unreeling and uncoiling methods that are most likely to cause kinks. Such improper procedures must be avoided in order to prevent the occurrence of loops. These loops, when pulled taut, will inevitably result in kinks. No matter how a kink develops, it will damage strands and wires, and the kinked section must be cut out. Proper and careful handling will keep the wire rope free from kinks.

Figure 22. Perhaps the most common and easiest uncoiling method is to hold one end of the rope while the coil is rolled along the ground.

Figure 23. Illustrating a *wrong* method of *unreeling* wire rope.

Figure 24. Illustrating a *wrong* method of *uncoiling* wire rope.

SEIZING WIRE ROPE

While there are numerous ways to cut wire rope, in every case, certain precautions must be observed. For one thing, proper seizings are always applied on both sides of the place where the cut is to be made. In a wire rope, carelessly or inadequately seized ends may become distorted and flattened, and the strands may loosen. Subsequently, when the rope is operated, there may be an uneven distribution of loads to the strands; a condition that will significantly shorten the life of the rope.

The two widely accepted methods of applying seizing are illustrated in Figures 25A and 25B. The seizing itself should be soft, or annealed wire or strand. Seizing wire diameter and the length of the seizing will depend on the diameter of the wire rope; the length of the seizing should never be less than the diameter of the rope being seized. Normally, for preformed ropes, one seizing on each side of the cut is sufficient. But for ropes that are not preformed or rotation resistant ropes, a minimum of two seizings on each side is recommended; and these should be spaced one rope diameter apart (Fig. 26).

Other methods of seizing may be acceptable depending on the level of preforming of the rope. Non-preformed or partially preformed ropes require special attention and correct seizing is very important. Seizing of preformed ropes may be accomplished by methods such as plastic wire ties, hose clamps, some types of tape, etc.

The most important factor in the seizing of any rope is that the rope does not deform and the rope lay does not change when the rope is cut.

Table 4 lists suggested seizing wire diameters for use with a range of wire rope diameters.

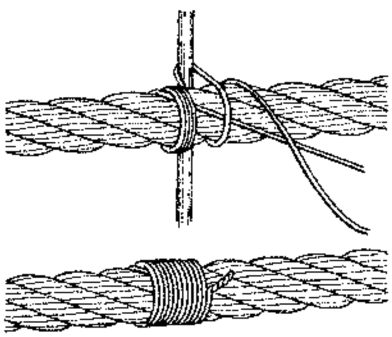


Figure 25A. METHOD A: Lay one end of the seizing wire in the groove between two strands; wrap the other end *tightly* in a close helix over a portion of the wire in the groove using a seizing iron (a round bar 1/2" to 5/8" diameter x 18" long) as shown above. Both ends of the seizing wire should be twisted together tightly, and the finished appearance as shown below. Seizing widths should not be less than the rope diameter.

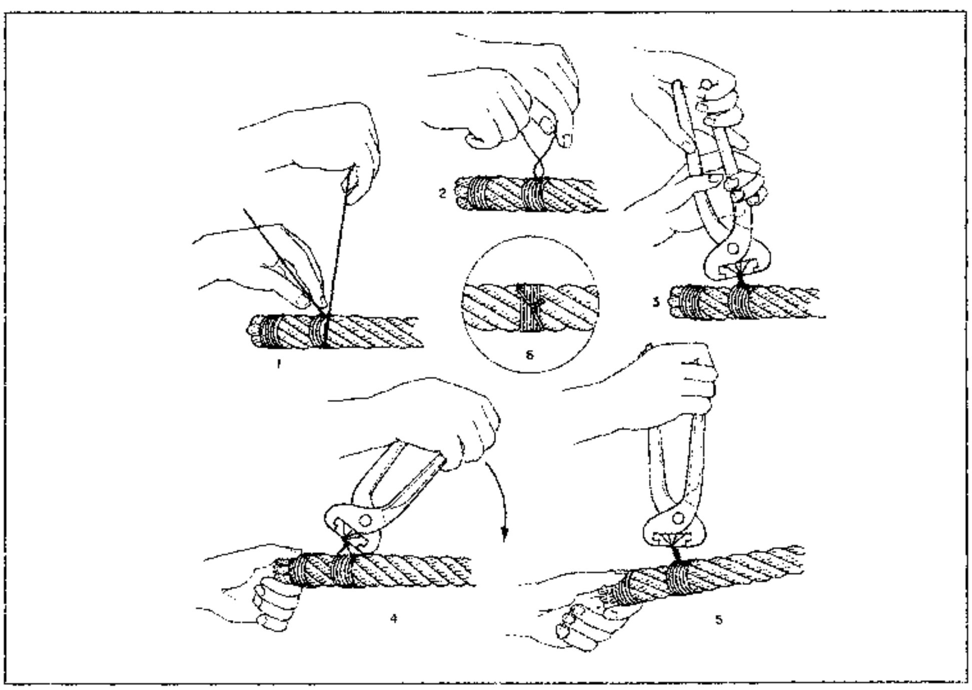


Figure 25B. METHOD B: The procedure illustrated at right is another method of seizing wire rope.

TABLE 4 SEIZING*

Rope Diameters inches	Rope Diameters mm	Suggested Seizing Wire Diameters** inches	Suggested Seizing Wire Diameters** mm
1/8 – 5/16	3.2-8.0	.032	0.813
3/8 – 9/16	9.5-14.5	.048	1.21
5/8 – 15/16	16.0-24.0	.063	1.60
1 – 1-5/16	26.0-33.0	.080	2.03
1-3/8 – 1-11/16	35.0-43.0	.104	2.64
1-3/4 and larger	45.0 and larger	.124	3.15

*Length of the seizing should not be less than the rope diameter.

**The diameter of seizing wire for elevator ropes is usually somewhat smaller than that shown in this table. Consult the wire rope manufacturer for specific size recommendations. Soft annealed seizing strand of an appropriate size may also be used.

CUTTING WIRE ROPE

Wire rope is cut after being properly seized (Fig. 26). Cutting is a reasonably simple operation provided appropriate tools are used. There are several types of cutters and shears commercially available, which are specifically designed to cut wire rope.

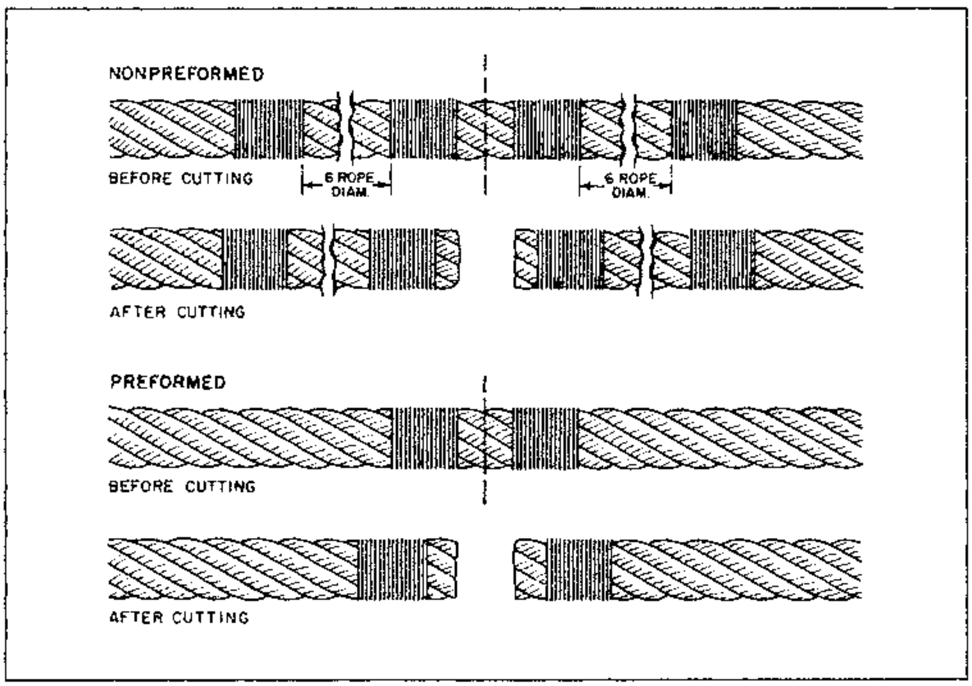


Figure 26. Seizings are applied *before* cutting.

END PREPARATIONS

For a number of applications—such as tight openings in drums, or other complicated reeving systems—there may be a need for making special end preparations. When these are required, there are four basic designs (and combinations) to choose from (Fig. 27). The maximum outside diameter of the end preparation should not exceed the actual rope diameter. Whenever possible end preparations should be removed after the rope is installed unless otherwise recommended by the rope manufacturer. Beckets are used when another rope is needed to pull the new rope into place. *Wire rope should not be shortened, lengthened or terminated by the use of a knot.*

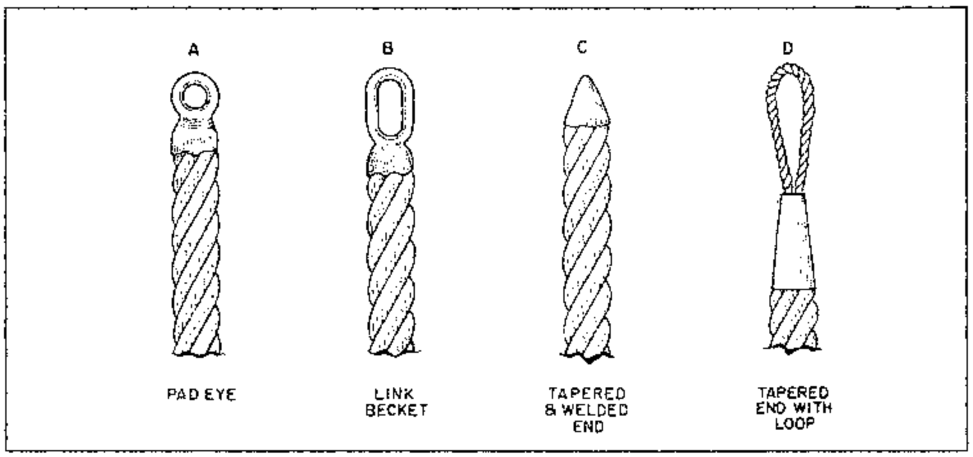


Figure 27. Beckets, or end preparations, are used on wire rope ends when another rope is needed to pull the operating rope into place. Four commonly used beckets are illustrated.

END TERMINATIONS

The rope end must be fastened to the mechanism so that force and motion are transferred efficiently. End terminations thus become items of great importance for transferring these forces. Each basic type of termination has its own individual characteristic. Hence, one type will usually fit the needs of a given installation better than the others.

It should be noted that not all end terminations will develop the full strength of the wire rope used. To lessen the possibility of error, the wire rope industry has determined terminal efficiencies for various types of end terminations. Holding power calculations can be made for the more popular end terminations (Fig. 28) based on efficiency factors in Table 5.

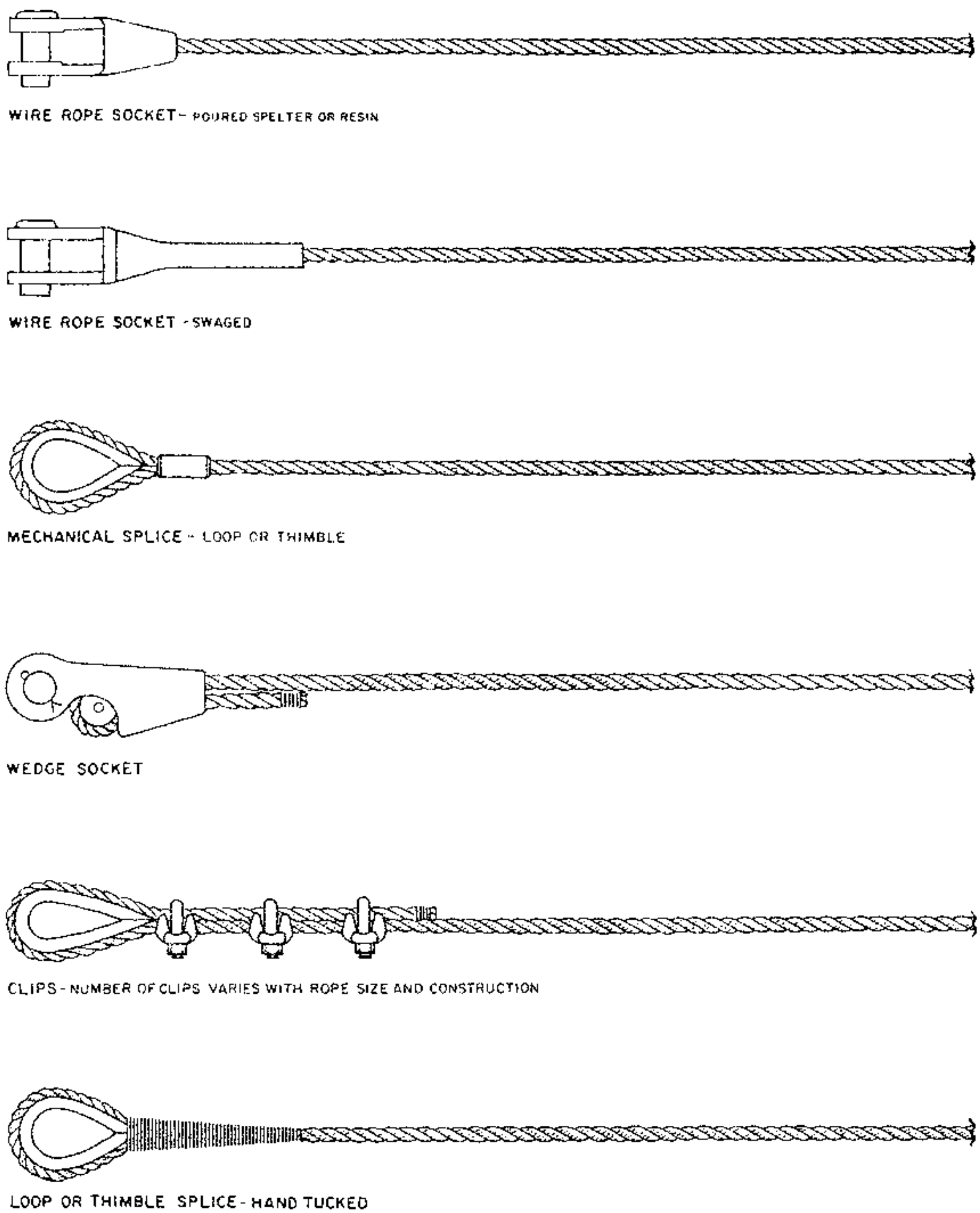


Figure 28. End fittings or terminations are available in many designs, some of which were developed for particular applications. The six shown are among the most commonly used.

TABLE 5 TERMINAL EFFICIENCIES (APPROXIMATE)
Efficiencies are applicable to the rope's minimum breaking force

Type of Termination	Efficiency Rope with IWRC*	Efficiency Rope with FC**
Wire Rope Socket (Spelter or Resin)	100%	100%
Swaged Socket (Regular Lay Ropes Only)	100%	(Not Recommended)
Mechanical Spliced Sleeve (Flemish Eye)		
1" dia. and smaller	95%	92-1/2%
Greater than 1" dia. through 2"	92-1/2%	90%
Greater than 2" dia. through 3-1/2"	90%	(Not established)
Loop or Thimble Splice-Hand Spliced (Tucked) (Carbon Steel Rope)		
1/4"	90%	90%
5/16"	89%	89%
3/8"	88%	88%
7/16"	87%	87%
1/2"	86%	86%
5/8"	84%	84%
3/4"	82%	82%
7/8" thru 2-1/2"	80%	80%
Loop or Thimble Splice-Hand Spliced (Tucked) (Stainless Steel Rope)		
1/4"	80%	
5/16"	79%	
3/8"	78%	
7/16"	77%	
1/2"	76%	
5/8"	74%	
3/4"	72%	
7/8"	70%	
Wedge Sockets*** (Depending on Design)	75% to 80%	75% to 80%
Clips*** (Number of clips varies with size of rope)	80%	80%

*IWRC=Independent Wire Rope Core **FC=Fiber Core

*** Typical values when terminations are correctly designed, applied and maintained. Refer to fittings manufacturers for exact values and method.

SOCKETING

Improperly attached wire rope terminals lead to serious—possibly unsafe—conditions. To perform properly all wire rope elements must be held securely by the terminal so that all parts of the rope are taking their proper share of the applied load.

Poured Sockets – Zinc or Resin

Poured sockets have traditionally been the method for determining the rope's actual breaking strength. All other types of terminations have been compared to poured sockets. Their efficiency is therefore established to be 100% for all grades and constructions of rope.

Rope assemblies with poured attachments are generally used as a straight tension member. In such cases, where the rope is used as a pendant line, the minimum recommended design factor is 3.0. If the assembly is used as a sling the minimum recommended design factor of 5.0 should be used to calculate the rated capacity.

Length tolerances for poured attachments can be somewhat more stringent than other types of assemblies. The manufacturer should be contacted and agreement reached before the order is placed. Tolerance as small as plus or minus 1/4" per 100'is not out of the ordinary for this type of assembly. Specifications such as type of firting, pin orientation (See Appendix B), whether zinc or resin should be used, and type of application should also be supplied to the manufacturer when ordering these types of assemblies.

When preparing a wire rope for socketing it is of extreme importance to follow procedures recommended by API (American Petroleum Institute) RP-9B or by ISO standards. Poured socketing should only be done by thoroughly trained personnel.

Several industry standards require that all zinc or resin poured sockets be prooftested after fabrication.

WIRE ROPE CLIPS

Wire rope clips are widely used for making end terminations.

Clips are available in two basic designs; the *U-bolt* and *double saddle* (Fig. 29). The efficiency of both types is the same.

When using *U-bolt* clips, extreme care must be exercised to make certain that they are attached correctly; i.e., the *U-bolt* must be applied so that the "U" section is in contact with the dead end of the rope (Fig. 30). Also, the tightening and retightening of the nuts must be accomplished as required.

Use only forged clips for critical, heavy duty, overhead loads, such as support lines, guy lines, towing lines, tie downs, scaffolds, etc.

Malleable clips are to be used for making eye termination assemblies only with right regular lay wire rope and only for light duty uses with small applied loads, such as hand rails, fencing, guard rails, etc.

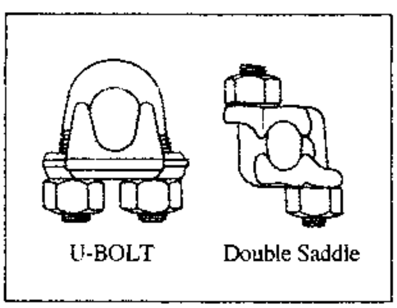


Figure 29. Wire rope clips are obtainable in two basic designs: U-Bolt and double saddle. Their efficiency is the same.

HOW TO APPLY CLIPS

U- BOLT CLIPS (Table 6, p.39)

Recommended Method of Applying U-Bolt Clips to Get Maximum Holding Power of the Clip. The following is based on the use of proper size U-Bolt clips on new rope.

1. Refer to Table 6 in following these instructions. Turn back specified amount of rope from thimble or loop. Apply first clip one base width from dead end of rope. Apply U-Bolt over dead end of wire rope with live end resting in saddle. Tighten nuts evenly, alternating from one nut to the other until reaching the recommended torque.

2. When two clips are required, apply the second clip as near the loop or thimble as possible. Tighten nuts evenly, alternating until reaching the recommended torque. When more than two clips are required, apply the second clip as near the loop or thimble as possible, turn nuts on second clip firmly, but do not tighten. Proceed to Step 3.

3. When three or more clips are required, space additional clips equally between first two - take up rope slack - tighten nuts on each U-Bolt evenly, alternating from one nut to the other until reaching recommended torque.

4. Apply first load to test the assembly. This load should be of equal or greater weight than loads expected in use. Next, check and retighten nuts to recommended torque.

In accordance with good rigging and maintenance practices, the wire rope and termination should be inspected periodically for wear, abuse, and general adequacy. Inspect periodically and retighten to recommended torque.

A termination made in accordance with the above instructions, and using the number of clips shown, has an approximate 80% efficiency rating. This rating is based upon the minimum breaking force of wire rope. If a pulley is used in place of a thimble for turning back the rope, add one additional clip.

The number of clips shown is based upon using right regular or lang lay wire rope, 6 x 19 classification or 6 x 36 classification, fiber core or IWRC; IPS, EIP or EEIP. If Seale construction or similar large outer wire type construction in the 6 x 19 classification is to be used for sizes 1 inch and larger, add one additional clip.

The number of clips shown also applies to rotation resistant right regular lay wire rope, 8 x 19 classification, and 19 x 7 classification, IPS, EIP and EEIP sizes 1-1/2 inch and smaller.

For other classifications of wire rope not mentioned above, it may be necessary to add additional clips to the number shown.

If a greater number of clips are used than shown in the table, the amount of rope turnback should be increased proportionately. **ABOVE BASED ON USE OF PROPER SIZE U-BOLT CLIPS ON NEW ROPE.**

IMPORTANT: *Failure to make a termination in accordance with aforementioned instructions, or failure to periodically check and retighten to the recommended torque, may cause a reduction in efficiency rating.*

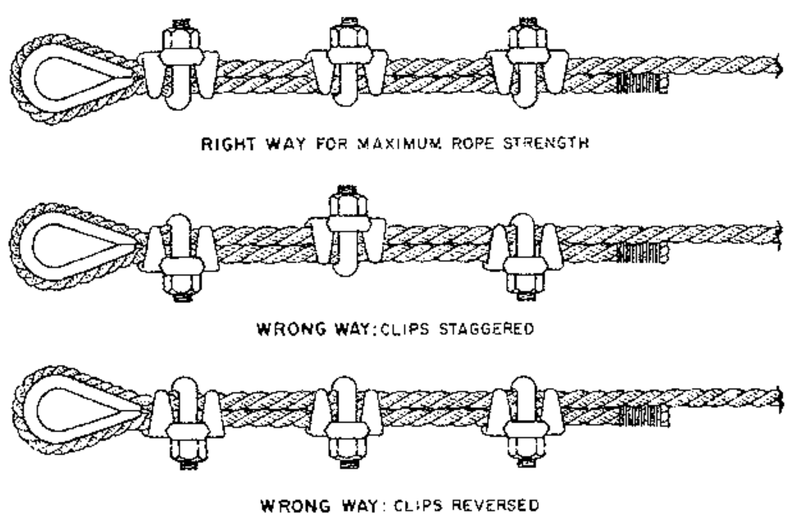
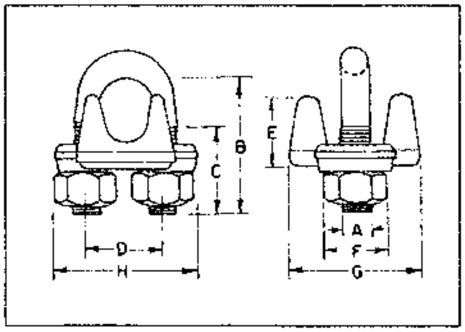


Figure 30. The correct way to attach U-bolts is shown at the top; the "U" section is in contact with the dead end of the rope and is clear of the thimble.



Dimensions in inches

TABLE 6 U-Bolt Clips*

Clip Size	A	B	C	D	E	F	G	H	Min. No. Of Clips	Amount of Rope To Turn Back	Torque In Ft.-Lbs.	Weight Pounds Per 100
1/8	.22	.72	.44	.47	.41	.38	.81	.94	2	3 1/4	4.5	6
3/16	.25	.97	.56	.59	.50	.44	.94	1.16	2	3 3/4	7.5	10
1/4	.31	1.03	.50	.75	.66	.56	1.19	1.44	2	4 3/4	15	20
5/16	.38	1.38	.75	.88	.72	.69	1.31	1.69	2	5 1/4	30	30
3/8	.44	1.50	.75	1.00	.91	.75	1.63	1.94	2	6 1/2	45	47
7/16	.50	1.88	1.00	1.19	1.03	.88	1.81	2.28	2	7	65	76
1/2	.50	1.88	1.00	1.19	1.13	.88	1.91	2.28	3	11 1/2	65	80
9/16	.56	2.25	1.25	1.31	1.22	.94	2.06	2.50	3	12	95	104
5/8	.56	2.38	1.25	1.31	1.34	.94	2.06	2.50	3	12	95	106
3/4	.62	2.75	1.44	1.50	1.41	1.06	2.25	2.84	4	18	130	150
7/8	.75	3.12	1.62	1.75	1.59	1.25	2.44	3.16	4	19	225	212
1	.75	3.50	1.81	1.88	1.78	1.25	2.63	3.47	5	26	225	260
1 1/8	.75	3.88	2.00	2.00	1.91	1.25	2.81	3.59	6	34	225	290
1 1/4	.88	4.25	2.12	2.31	2.19	1.44	3.13	4.13	7	44	360	430
1 3/8	.88	4.63	2.31	2.38	2.31	1.44	3.13	4.19	7	44	360	460
1 1/2	.88	4.94	2.38	2.59	2.44	1.44	3.41	4.44	8	54	360	540
1 5/8	1.00	5.31	2.62	2.75	2.66	1.63	3.63	4.75	8	58	430	700
1 3/4	1.13	5.75	2.75	3.06	2.94	1.81	3.81	5.28	8	61	590	925
2	1.25	6.44	3.00	3.38	3.28	2.00	4.44	5.88	8	71	750	1300
2 1/4	1.25	7.13	3.19	3.88	3.19	2.00	4.50	6.38	8	73	750	1600
2 1/2	1.25	7.69	3.44	4.13	3.69	2.00	4.05	6.63	9	84	750	1900
2 3/4	1.25	8.31	3.56	4.38	4.88	2.00	5.00	6.88	10	100	750	2300
3	1.50	9.19	3.88	4.75	4.69	2.38	5.88	7.63	10	106	1200	3100
3 1/2	1.50	10.75	4.50	5.50	6.00	2.38	6.19	8.38	12	149	1200	4000

If a pulley (sheave) is used for turning back the wire rope, add one additional clip.

If a greater number of clips are used than shown in the table, the amount of turnback should be increased proportionately.

The tightening torque values shown are based upon the threads being clean, dry, and free of lubrication.

Above values do not apply to plastic coated wire rope.

*From the Crosby Group

DOUBLE SADDLE CLIPS

Recommended Method of Applying Double Saddle Clips to Get Maximum Holding Power of the Clip. The following based on the use of proper size double saddle clips on new rope.

1. Refer to Table 7 in following these instructions. Turn back specified amount of rope from thimble or loop. Apply first clip one base width from dead end of rope. Tighten nuts evenly, alternating from one nut to the other until reaching the recommended torque.

2. When two clips are required, apply the second clip as near the loop or thimble as possible. Tighten nuts evenly, alternating until reaching the recommended torque. When more than two clips are required, apply the second clip as near the loop or thimble as possible. Turn nuts on second clip firmly, but do not tighten. Proceed to Step 3.

3. When three or more clips are required, space additional clips equally between first two—take up rope slack—tighten nuts on each double saddle evenly, alternating from one nut to the other until reaching recommended torque.

4. Apply first load to test the assembly. This load should be of equal or greater weight than loads expected in use. Next, check and retighten nuts to recommended torque.

In accordance with good rigging and maintenance practices, the wire rope and termination should be inspected periodically for wear, abuse, and general adequacy. Inspect periodically and retighten to recommended torque.

A termination made in accordance with the above instructions, and using the number of clips shown has an approximate 80% efficiency rating. This rating is based upon the minimum breaking force of wire rope. If a pulley is used in place of a thimble for turning back the rope, add one additional clip.

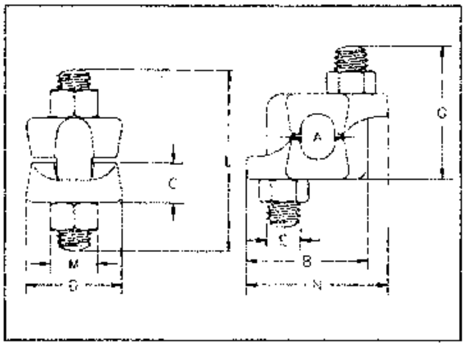
The number of clips shown is based upon using right regular or lang lay wire rope, 6 x 19 classification or 6 x 36 classification , fiber core or IWRC, IPS, EIP or EEIP. If Seale construction or similar large outer wire type construction in the 6 x 19 classification is to be used for sizes 1 inch and larger, add one additional clip.

The number of clips shown also applies to rotation resistant right regular lay wire rope, 8 x 19 classification and 19x7 classification, IPS, EIP and EEIP, sizes 1-1/2 inch and smaller.

For other classifications of wire rope not mentioned above, it may be necessary to add additional clips to the number shown.

If a greater number of clips are used than shown in the table, the amount of rope turnback should be increased proportionately. **ABOVE BASED ON USE OF PROPER SIZE DOUBLE SADDLE CLIPS ON NEW ROPE.**

IMPORTANT: *Failure to make a termination in accordance with aforementioned instructions, or failure to periodically check and retighten to the recommended torque, may cause a reduction in efficiency rating.*



Dimensions in inches

TABLE 7 DOUBLE – SADDLE CLIPS*

Clip Size	A	B	C	D	E	G	L Approx.	M	N	Min. No. of clips	Amount of rope to turn back	Torque in ft/lb	Weight lb/100
3/16-1/4	.25	1.25	.34	.94	.38	1.28	1.63	.69	1.47	2	4	30	18
5/16	.31	1.34	.44	1.06	.38	1.47	1.94	.69	1.56	2	5	30	28
3/8	.38	1.59	.50	1.06	.44	1.81	2.38	.75	1.88	2	5 1/4	45	40
7/16	.50	1.88	.56	1.25	.50	2.19	2.75	.88	2.19	2	6 1/2	65	70
1/2	.50	1.88	.56	1.25	.50	2.19	2.75	.88	2.19	3	11	65	70
9/16	.63	2.28	.69	1.50	.63	2.69	3.50	1.06	2.63	3	12 3/4	130	100
5/8	.63	2.28	.69	1.50	.63	2.69	3.50	1.06	2.63	3	13 1/2	130	100
3/4	.75	2.69	.88	1.81	.75	2.94	3.75	1.25	3.06	3	16	225	175
7/8	.88	2.97	.97	2.13	.75	3.31	4.13	1.25	3.14	4	26	225	225
1	1.00	3.06	1.19	2.25	.75	3.72	4.63	1.25	3.53	5	37	225	300
1 1/8	1.13	3.44	1.28	2.38	.88	4.19	5.25	1.44	3.91	5	41	360	400
1 1/4	1.25	3.56	1.34	2.50	.88	4.25	5.25	1.44	4.03	6	55	360	400
1 3/8	1.50	4.13	1.56	3.00	1.00	5.56	7.00	1.63	4.66	6	62	500	700
1 1/2	1.50	4.13	1.56	3.00	1.00	5.56	7.00	1.63	4.66	7	78	500	700

If a pulley (sheave) is used for turning back the wire rope, add one additional clip.

If a greater number of clips are used than shown in the table, the amount of turnback should be increased proportionately

The tightening torque values shown are based upon the threads being clean, dry, and free of lubrication.

Above values do not apply to plastic coated wire rope.

*From the Crosby Group

WEDGE SOCKETS

One of the more popular end attachments for wire rope is the *wedge socket*. For field, or on the job attachment, it is easily installed and quickly dismantled. There are two basic types of wedge sockets, the standard type and a special type with a wedge design that protrudes from the nose of the socket allowing a wire rope clip to be attached to the dead end of the rope. The following procedures are important for safe application of wedge sockets:

Inspection/Maintenance Safety

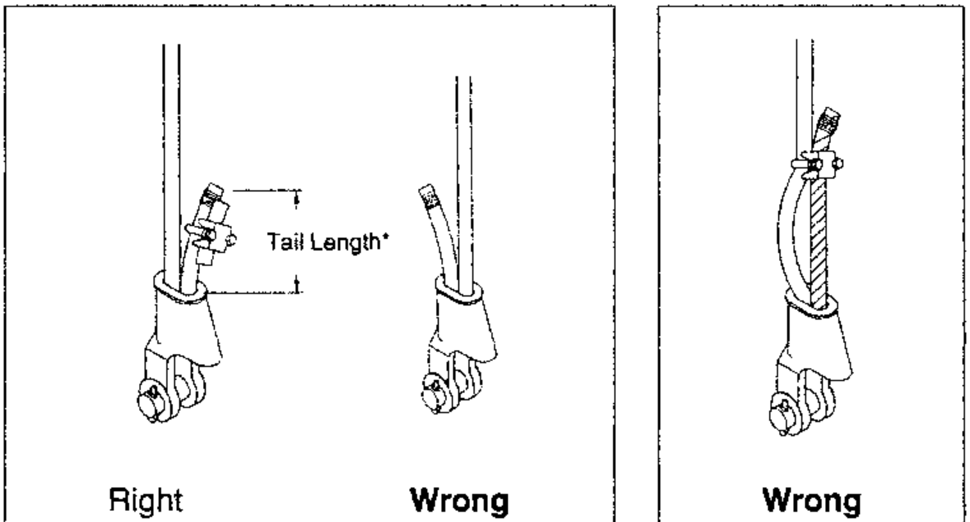
- Always inspect socket, wedge and pin for correct size and condition before using.
- Do not use parts showing cracks.
- Do not use modified or substitute parts.
- Repair minor nicks or gouges to socket or pin by lightly grinding until surfaces are smooth. Do not reduce original dimension more than 10%. Do not repair by welding.
- Inspect permanent assemblies annually, or more often in severe operating conditions. Consult the socket manufacturer for recommendations regarding the speeific use and reapplication of wedge sockets.

Assembly Safety

- Use only with wire rope constructions recommended by the socket or rope manufacturer. For intermediate size rope, 9/16" diameter and larger, use next larger size socket. For example: When using 9/16" diameter wire rope use a 5/8" Wedge Socket Assembly. Ensure that the dead end of the rope is seized, welded or brazed (or consult rope manufacturer) before inserting into the wedge socket. The tail length of the dead end should be a minimum of 6 rope diameters.
- Align live end of rope with center line of pin. (See Figure 31)
- Secure dead end section of rope. (See Figure 31)
- **Do not attach dead end to live end.** (See Figure 31)
- Use a hammer to seat wedge and rope as deep into socket as possible before applying first load.
- **To use with Rotation Resistant wire rope**, ensure that the dead end is seized, welded or brazed (or consult rope manufacturer) before inserting the wire rope into the wedge socket to prevent core slippage or loss of rope lay. The tail length of the dead end should be a minimum of 20 rope diameters but not less than 6" (See Figure 31).

Operating Safety

- Apply first load to fully seat the wedge and wire rope in the socket. This load should be of equal or greater weight than loads expected in use.
- Efficiency rating of the wedge socket termination is based upon the minimum breaking force of wire rope. The efficiency of a properly assembled wedge socket is 80%.
- During use, do not strike the dead end section with any other elements of the rigging (called two blocking).
- Do not shock load.



* Tail Length
Standard 6 to 8 strand wire rope
A minimum of 6 rope diameters, but not less than 6".
(i.e. - For 1" rope: Tail Length = 1"x6=6")

Rotation Resistant Wire Rope
A minimum of 20 rope diameters, but not less than 6".
(i.d. - For 1" rope: Tail Length = 1"x20=20")

Figure 31. The wedge socket is a very popular end attachment; it is easily installed and quickly dismantled. But it must be applied correctly.

DRUMS—GROOVED

Drums are the means by which power is transmitted to the rope and then to the object to be moved. For the wire rope to pick up this power efficiently and to transmit it properly to the working end, installation must be carefully controlled.

If the drum is grooved, the winding conditions should be closely supervised to assure adherence to the following recommended procedures:

1) The end of the rope must be secured to the drum by such means as will give the end termination at least as much strength as is specified by the equipment manufacturer.
2) Adequate tension must be maintained on the rope while it is being wound so that the winding proceeds under continuous tension. Back tension applied to the rope during installation should be from 2 to 5% of the minimum breaking force of the rope being installed.
3) The rope must follow the groove.
4) It is preferable to have at least three dead wraps remaining on the drum when the rope is unwound during normal operation. Two dead wraps are a mandatory requirement in many codes and standards.

If the wire rope is carelessly wound and, as a result, jumps the grooves, it will be crushed and cut where it crosses from one groove to the other. Another, almost unavoidable problem is created at the drum flange; as the rope climbs to a second layer there is further crushing and the wires receive exeessive abrasion. Riser and filler strips may help remedy this condition.

Another factor that must be given serious consideration is the pitch of the drum grooves relative to the actual rope diameter. Wire rope is normally manufactured to a plus tolerance. (See Table 3.) The oversize tolerance of the rope must be taken into account or the rope will be damaged by poor spooling caused by a groove pitch that is either too small or too large.

As an example, a grooved drum made for 1/4-inch rope may have a pitch of .250 inches. Yet, by Federal standards, a 1/4-inch rope may have a diameter as large as .265 inches. If a rope of this size were to be operated on a drum with a .250 inch pitch, crowding would occur and the rope would be forced out of the groove.

DRUMS–PLAIN (SMOOTH)

Installation of a wire rope on a plain (smooth) face drum requires a great deal of care. The starting position should be at the correct drum flange so that each wrap of the rope will wind tightly against the preceding wrap (Fig. 32). Here too, close supervision should be maintained during installation. This will help make certain that:

1) The rope is properly attached to the drum.
2) Appropriate tension on the rope is maintained as it is wound on the drum. Back tension applied to the rope during installation should be from 2 to 5% of the minimum breaking force of the rope being installed.
3) Each wrap is guided as close to the preceding wrap as possible, so that there are no gaps between wraps.
4) It is preferable to have at least three dead wraps remaining on the drum when the rope is unwound during normal operation. Two dead wraps are a mandatory requirement in many codes and standards.

Loose and uneven winding on a plain (smooth) faced drum can and usually does create excessive wear, crushing and distortion of the rope. The results of such abuse are shorter service life and a reduction in the rope's effective strength. Also, for an operation that is sensitive in terms of moving and spotting a load, the operator will encounter control difficulties as the rope will pile up, pull into the pile and fall from the pile to the drum surface. The ensuing shock can break or otherwise damage the rope.

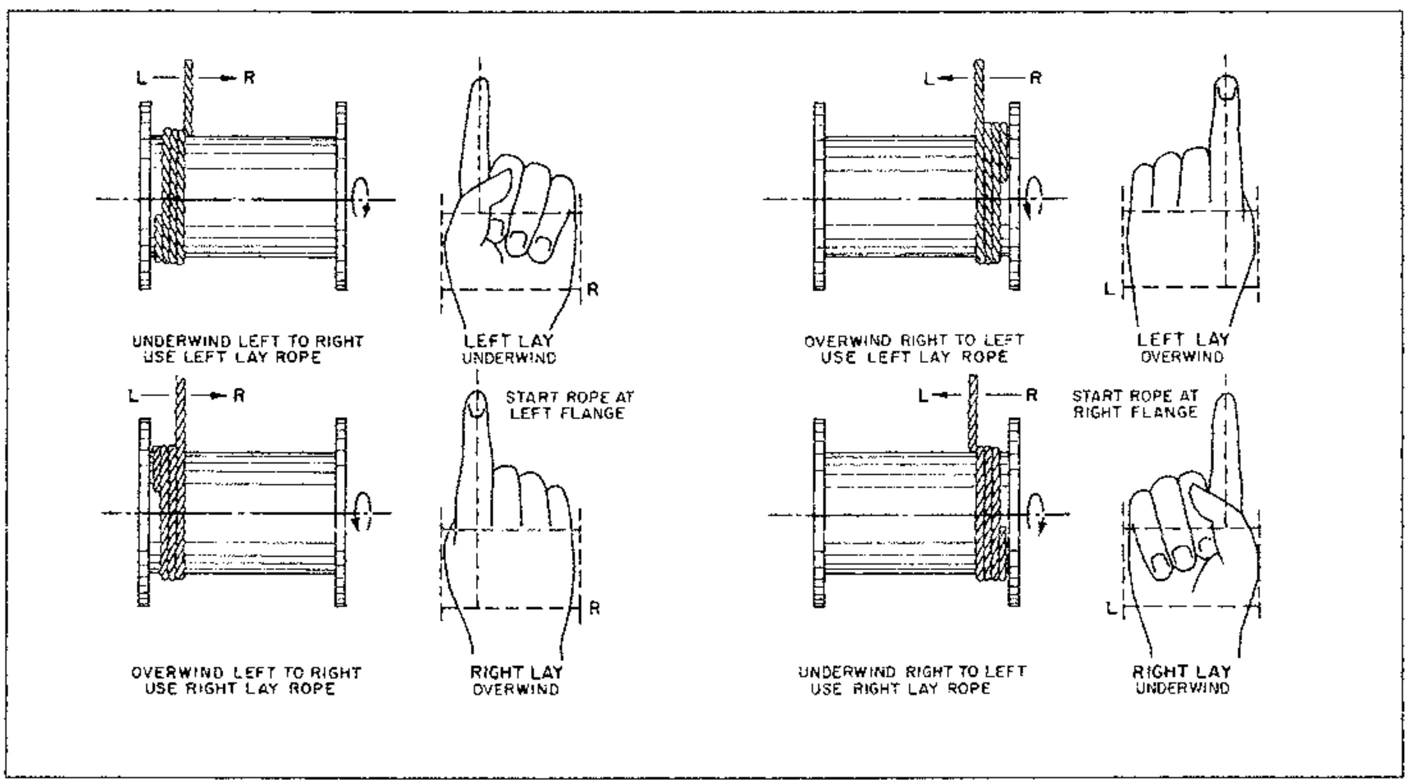


Figure 32. By holding the right or left hand with index finger extended, palm up or palm down, the proper procedure for applying left-and right-lay rope on a smooth drum can be easily determined.

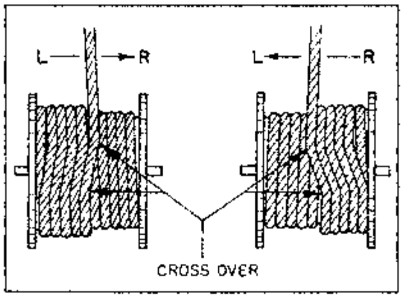


Figure 33. After the first layer is wound on a drum, the point at which the rope winds back for each wrap is called the *cross-over*.

The proper direction of winding the first layer on a smooth drum can be determined by standing behind the drum and looking along the path the rope travels, and then following one of the procedures illustrated in Figure 32. The diagrams show: the correct relationship that should be maintained between the direction of lay of the rope (right or left), the direction of rotation of the drum (overwind or underwind) and winding from left to right or right to left.

DRUMS—MULTIPLE LAYERS

Many installations are designed with requirements for winding more than one layer of wire rope on a drum. Winding multiple layers presents some further problems.

The first layer should wind in a smooth, tight helix which, if the drum is grooved, is already established. The grooves allow the operator to work off the face of the drum, and permit the minimum number of dead wraps.

A smooth drum presents an additional problem, initially, as the wire rope must be wound in such a manner that the first layer will be smooth and uniform and will provide a firm foundation for the layers of rope that will be wound over it. The first layer of rope on the smooth drum should be wound with tension (2 to 5% of the minimum breaking force of the rope) sufficient to assure a close helix - each wrap being wound as close as possible to the preceding wrap. The first layer then acts as a groove which will guide the successive layers. Unlike wire ropes operating on grooved drums, *the first layer should not be unwound* from a smooth-faced drum with multiple layers.

After the rope has wound completely across the face of the drum (either smooth or grooved), it is forced up to a second layer at the flange. The rope then winds back across the drum in the opposite direction, lying in the valleys between the wraps of the rope on the first layer. Advancing across the drum on the second layer, the rope, following the "grooves" formed by the rope on the first layer, actually winds back one wrap in each revolution of the drum. The rope must then cross one or two rope "grooves" (depending upon the type of grooving – single or double cross-over) in order to advance across the drum for each turn. The point at which this occurs is known as the *cross-over*. Cross-over is unavoidable on the second, and all succeeding layers. Figure 33 illustrates the winding of a rope on the second layer from left to right, and from right to left-the direction is shown by the arrows.

At these cross-over points, the rope is subjected to severe abrasion and crushing as it is pushed over the "grooves" and rides across the crown of the first rope layer. The scrubbing of the rope, as this is happening, can easily be heard.

There are, however, special drum groovings available that will greatly minimize the damage that can occur at cross-over points - e.g. Counterbalance Drum Grooving* with a double cross-over.

*Developed by LeBus International Engineers, Inc., Longview, Texas

Helical grooving does not employ a built in cross-over and does not work as well for multiple layer spooling as a counterbalanced drum because it does not have the cross-over and does not consistently put the rope in the proper position at the flanges to rise from one layer to the next layer.

Counterbalance grooving with two cross-overs is made so that each wrap of rope winds parallel to the drum flange for a distance less than half the circumference around the drum, then follows a short cross-over to complete half the drum circumference. The cross-over is at an angle with the drum flange and displaces the rope laterally by half the pitch of grooving.

Around the other half of the drum circumference each wrap again winds parallel to the flange for a distance, and then follows another short cross-over to a point one full circumference from the start. At this point the lateral displacement is equal to the full pitch of grooving.

The grooving for this type of winding is similar to the parallel grooving except that half the drum circumference is laterally displaced from the other half by half the pitch of grooving, and between these two halves the grooves make short cross-overs to guide the rope properly. The two cross-over areas are on opposite sides of the drum, or 180° apart.

Since the lateral displacement of each cross-over is one half the pitch of grooving, or one half the displacement of the cross-overs encountered with other types of winding, "throw" of the rope is reduced, decreasing the whipping action. However, if the interval between these displacements happens to match the rope's vibration cycle, whipping can still become severe because this action is cumulative.

Since the cross-over areas are spaced opposite each other, or 180° apart, raised portions of the winding caused by vertical displacement at the cross-overs also occur opposite each other. These raised sections become quite pronounced where many layers are involved and the balancing effect of keeping them opposite gave name to the method.

With counterbalance winding, the change of layers can be controlled better than with other systems and is preferred when a rope must wind in many layers on the drum.

5 Operation, Inspection and Maintenance of Wire Rope

SHEAVES AND DRUMS

In the course of normal operations, wire ropes may come into contact with sheaves, drums, rollers and other parts of the equipment on which it operates —all of which must be maintained in good condition. This contact can cause wear in both the equipment part and the wire rope.

This wear, which is normal and expected, occurs because wire rope, when loaded, stretches much like a coil spring. For example, when a rope is bent over a sheave, the rope's load-induced stretch causes it to rub against the groove. As a result, both the groove and rope are subject to wear. Within the rope itself, additional wear is encountered as the rope adjusts—by the adjustment or movement of the wires and strands—while bent around the sheave or drum. The smaller the ratio of sheave diameter to rope diameter (D/d), the greater the adjusting movement, and the more rapid the resulting wear.

The amount of wear, and the speed at which it takes effect on both the wire rope and grooves of the sheave or drum, are also determined by the sheave material, and the radial pressure between rope and groove. Simply stated, excessive wear can be caused either by sheave or drum material that is too soft, or a diameter (tread diameter) that is too small.

To determine the unit radial pressure between rope and groove, use the following formula:

$$p = \frac{2T}{Dd}$$

where p = Unit radial pressure in pounds per square inch
T = Load on the rope in pounds
D = Tread diameter of the sheave or drum in inches
d = Nominal diameter of the rope in inches

Table 8 gives examples of allowable unit radial bearing pressures of ropes on various materials commonly used in sheaves and drums. The values given are typical for the materials listed; they are not precise values since these materials are made to a wide range of specifications.

In the foregoing equation, if the calculated value of "p" exceeds the allowable radial pressure for the sheave or drum material, the groove will wear quite rapidly. Wear will manifest itself in the form of either sheave groove wear or corrugation (See Fig. 52)—either of which will contribute to accelerated wear in the rope.

Values for the allowable unit radial pressures given in Table 8 are intended solely as a user's guide; use of these figures does not guarantee prevention of sheave or drum wear. Further, the values should not be taken as restrictive with regard to other or new materials.

There are, for example, certain elastomers in current use, but there is insufficient data to support clear recommendations. It is best for the user to contact the elastomer or device manufacturer for specific recommendations.

Note: All verification tests of retirement criteria (See Table 14) apply to wire rope operating on steel sheaves and/or drums. The user shall contact the sheave, drum or crane manufacturer, or a qualified person for broken wire removal criteria for wire ropes operating on sheaves or drums made of materials other than steel.

TABLE 8
SUGGESTED ALLOWABLE RADIAL BEARING PRESSURES OF ROPES ON VARIOUS SHEAVE MATERIALS IN POUNDS PER SQUARE INCH

Material	Regular Lay Rope, psi				Lang Lay Rope, psi			Flattened Strand Lang Lay psi	Remarks
	6 x 7	6 x 19	6 x 36	8 x 19	6 x 7	6 x 19	6 x 36		
Cast Iron	300	480	585	680	350	550	660	800	Based on minimum Brinell hardness of 125
Carbon Steel Casting	550	900	1075	1260	600	1000	1180	1450	30-40 Carbon. Based on minimum Brinell hardness of 160
Chilled Cast Iron	650	1100	1325	1550	715	1210	1450	1780	Not advised unless surface is uniform in hardness.
Manganese Steel, Induction Hardened, or Flame Hardened	1470	2400	3000	3500	1650	2750	3300	4000	Grooves must be ground and sheaves balanced for high-speed service.

BENDING WIRE ROPE OVER SHEAVES AND DRUMS

Sheaves, drums and rollers must be of a correct design if optimum service is to be obtained from both the equipment and the wire rope. Because there are many different types of equipment and many different operating conditions, it is difficult to identify the one specific size of sheave or drum most appropriate for every application.

The guideline to follow is this: the most practical design is the one that most closely accommodates the limiting factors imposed by the equipment, the operating conditions and the wire rope.

All wire ropes operating over sheaves and drums are subjected to cyclic bending stresses, thus the rope wires will eventually fatigue. The magnitude of these stresses depends—all other factors being constant—upon the ratio of the diameter of the sheave or drum to the diameter of the rope. Frequently, fatigue from cyclic, high-magnitude bending stress is a principal reason for shortened rope service.

In order for a rope to bend around a sheave, the rope's strands and wires must move relative to one another. This movement compensates for the difference in diameter between the underside and the top side of the rope, the distance being greater along the top side than it is on the underside next to the groove. Proper rope movement (and service) is adversely affected if the wires cannot adjust to compensate for this length differential. Also, there can be additional limitations to wire movement because of excessive pressure caused by a sheave groove diameter which is too small, or by lack of rope lubrication. Avoid changing the bending direction from one sheave to another as this reverse bending further accelerates wire fatigue.

The relationship between sheave diameter and rope diameter is a critical factor that is used to estimate the rope's fatigue resistance or relative service life. It is expressed in the D/d ratio mentioned earlier in which D is the pitch diameter of the sheave and d is the diameter of the rope. Table 9 lists suggested minimum D/d values for various rope constructions. Other values are permitted by various standards such as those listed in Table 10. Smaller values can affect rope life. Table 11 and Figure 34 show the effect of rope construction and D/d on service life.

BREAKING IN A NEW WIRE ROPE

A new wire rope requires careful installation and following all the appropriate guidelines previously noted. After the rope is installed and the ends secured in the correct manner, the equipment should be started carefully and then permitted to run through a cycle of operation at very slow speed. During this trial operation, closely watch all working parts—sheaves, drums, rollers—to make certain that the rope runs freely, and without any possible obstructions as it makes its way through the system. If no problems appear in running the rope, the next step should include several repititions of the normal operational cycle under increasing loads and speeds. This procedure allows the component parts of the new rope to make a gradual adjustment to the actual operating conditions. Taking the time and effort to perform these breaking in procedures should result in obtaining the optimum service life from the wire rope.

TABLE 9 SUGGESTED SHEAVE AND DRUM RATIOS

These D/d ratios are based on sheave and drum diameters being approximately 400 times the outer wire diameter of the rope. For rope constructions not listed, consult the rope manufacturer.

Construction	Suggested D/d Ratio*
6 x7	42
19 x 7 or 18 x 7 Rotation Resistant 6 x 19 S	34
6 x 25 B Flattened Strand 6 x 27 H Flattened Strand 6 x 30 G Flattened Strand 6 x 31V Flattened Strand 6 x 21 FW 6 x 26 WS	30
8 x 19 S 7 x 21 FW 6 x 25 FW 6 x 31 WS 6 x 37 FWS	26
7 x 25 FW 6 x 36 WS 6 x 43 FWS 7 x 31 WS	23
6 x 41 WS 6 x 41 SFW 6 x 49 SWS 7 x 36 WS 8 x 25 FW 19 x 19 Rotation Resistant 35 x 7 Rotation Resistant	20
6 x 46 SFW 6 x 46 WS 8 x 36 WS	18

* D=Pitch diameter of sheave
d=nominal diameter of rope

To find any pitch diameter from this table, the diameter for the rope construction to be used is multiplied by its nominal diameter (d). For example, the minimum sheave pitch diameter for a 1/2" 6 x 21 FW rope would be 1/2" (nominal diameter) x 30 (minimum ratio) or 15".

TABLE 10 REQUIREMENTS IN STANDARDS FOR SHEAVE AND DRUM D/d RATIOS

Type of Equipment	Specification or Standard	Application	Minimum D/d Ratio Drum	Minimum D/d Ratio Sheave
Mobile Cranes	ASME B30.5	Load Hoist	18	18
		Boom Hoist	15	15
		Load Block		16
Tower Crane	ASME B30.3	Hoist Rope	18	Top 18 Traveling 16
Mine Hoist	ANSI M11.1*	Drum Hoist Rope		
		Over 1"	80	80
		1" and under	60	60
		Friction Hoist Rope		
		Flattened Strand	80	80
		Full Lock Coil	100	100
Surface Mining	ANSI M11.1*	Hoist Ropes	24	24
		Drag Ropes	22	22
Rotary Drilling	API 9B	Drill Line	20	30
Offshore Pedestal Crane	API 2C	Hoist Rope/ Boom Hoist Rope	18	18
Ski Lifts	ANSI B77.1	Fixed Grip Lifts	80(Bull Wheel)	
		Detachable Grip Lifts	72(Bull Wheel)	
Elevators	ASME A17.1	Suspension/Hoist	40	40
		Compensating		32

Note: Most standards minimum sheave and drum D/d ratios are based on the D being pitch diameter. API 9B and ANSI B77.1 use the tread diameter for D.

* Standard expired; values included as a reference.

If a change in construction is being considered as a means of obtaining longer service on a rope influenced principally by bending stresses, this table of factors may be useful. For example: a change from a 6 x 25 FW with a factor of 1.00 to a 6 x 36 WS with a factor of 1.15 would mean the service life could be estimated to increase 1.15 times or 15%.

These factors apply only for bending stresses. There are other factors, which are almost always present in rope operation, that contribute to rope deterioration. These other factors are not considered in this table.

TABLE 11 RELATIVE BENDING LIFE FACTORS

Rope Construction	Factor	Rope Construction	Factor
6 x 7 or 7 x 7 Aircraft	.60	7 x 25 FW	
19 x 7 or 18 x 7 R.R.	.70	6 x 29 FW	
6 x 19 S	.80	6 x 36 WS	
6 x 19 W		6 x 36 SFW	1.15
6 x 21 FW		6 x 43 FWS	
6 x 26 WS		7 x 31 WS	
6 x 25B FS	.90	8 x 25 FW	
6 x 27H FS		6 x 41 WS	
6 x 30G FS		6 x 41 SFW	1.25
6 x 31V FS		6 x 49 SWS	
7 x 21F W		7 x 36 FW	
6 x 25 FW	1.00	6 x 46 SFW	
6 x 31 WS		6 x 46 WS	
8 x 19S		8 x 36 WS	1.35
8 x 21 FW	1.10	6 x 61 FWS	
		6 x 57 SFWS	

*Note: This table, with some modifications, is based on outer wire diameter relationships. For rope constructions not listed, consult the rope manufacturer.

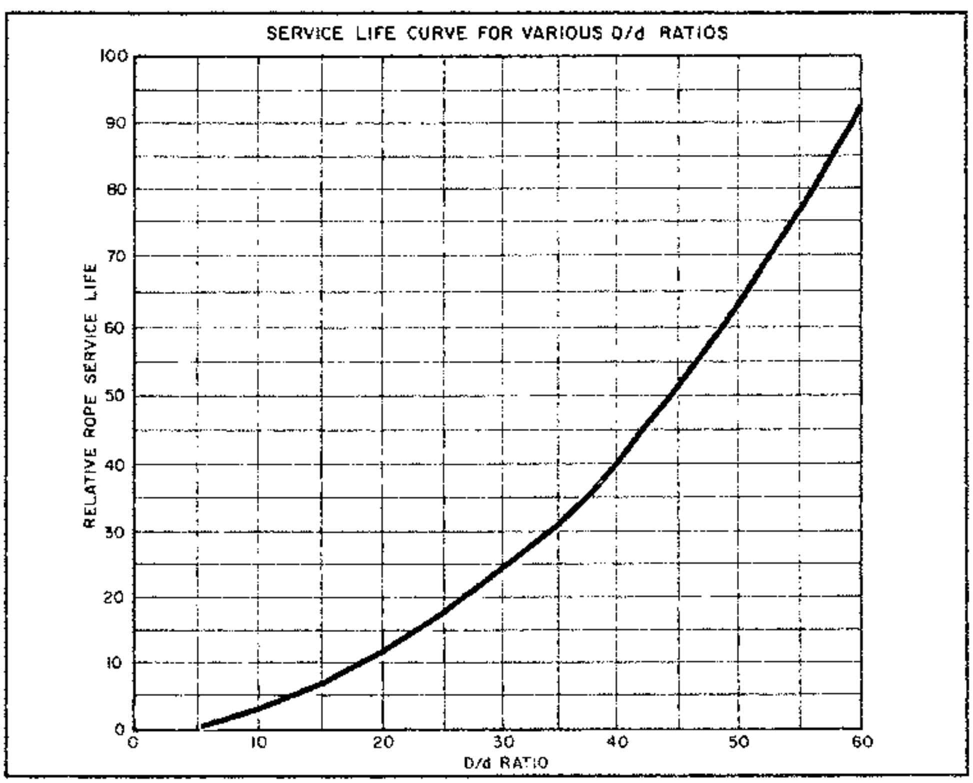


Figure 34. This service life curve only takes into account bending and tensile stresses. This curve can be utilized to predict comparative service life of a specific wire rope with varying D/d ratios. That resultant comparison is illustrated by the following example: A rope working with a D/d ratio of 26 has a relative service life of 17. If the same rope works over a sheave that increases its D/d ratio to 35, the relative service life increases to 32. In short, if this rope is used on the larger sheave, one could estimate an increase in its bending service life from 17 to 32 or an 88% increase.

INSPECTION OF SHEAVES AND DRUMS

Under normal conditions, machines receive inspections on a regular basis, and their overall condition is recorded. Such inspections usually include the drum, sheaves, and any other parts that may contact the wire rope and subject it to wear. As an additional precaution, rope related working parts, particularly in the areas described below, should be reinspected prior to the installation of a new wire rope.

The first item to be checked when examining sheaves and drums, is the condition of the grooves (Figs. 35, 36, and 37). To check the size, contour and amount of wear, a *groove gauge* is used. As shown in Figure 35, the gauge should contact the groove for about 150° of arc.

Two types of groove gauges are in general use and it is important to note which of these is being used. The two differ by their respective percentage *over nominal rope diameter.*

For new or remachined grooves, the groove gauge is nominal plus the full oversize percentage (5%). The gauge used by most wire rope inspectors today is sized at the nominal rope diameter plus 2-1/2% and is called a "Minimum for Worn Groove" gauge.

This latter gauge is intended to aet as a type of "no-go" gauge. Any sheave with a groove smaller than this should be regrooved or replaced. If that action is not taken in a reasonable amount of time, the rope will be damaged.

When the sheave is regrooved it should be machined to the dimensions for "recommended minimum new groove" given in Table 12. This table lists the requirements for new or re-machined grooves, giving the groove diameter in terms of the nominal wire rope diameter plus a percentage. Similarly, the size of the "no-go" gauge is given, against which worn grooves are judged. Experience has clearly demonstrated that the service life of the wire rope will be increased by following these standards.

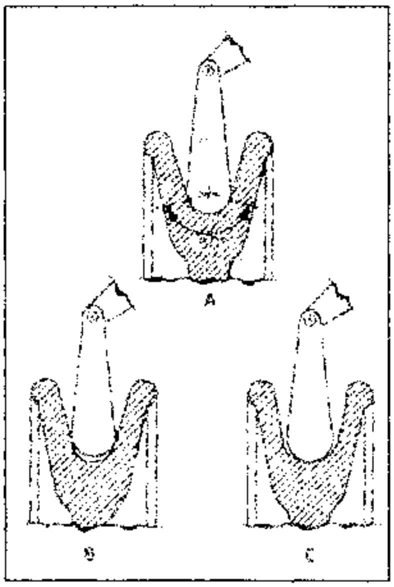


Figure 35. Cross sections illustrating three sheave groove conditions. A is correct, B is too tight, and C is too loose.

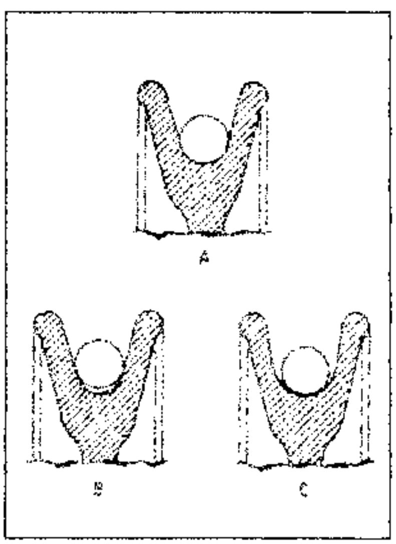


Figure 36. These sheave groove cross sections represent three wire rope seating conditions: A, a new rope in a new groove; B, a new rope in a worn groove; and C, a worn rope in a worn groove. (See also Figs. 35 and 37.)

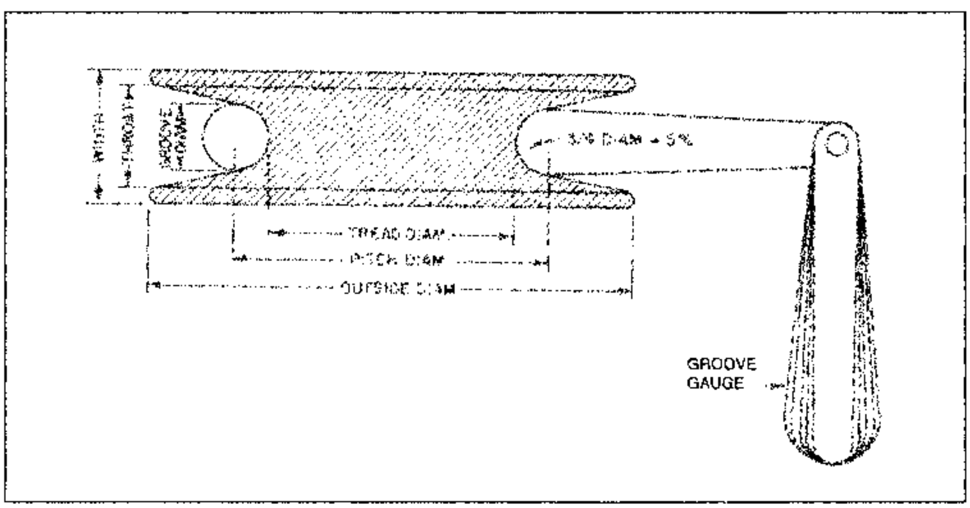


Figure 37. Illustrating the various dimensions of a sheave, and the use of a sheave gauge.

TABLE 12 GENERAL PURPOSE ROPES SHEAVE AND DRUM GROOVE DIMENSIONS*

Nominal Rope Diameter		Groove Radius					
		Minimum Worn Groove		Recommended Minimum New Groove		Maximum Groove	
inches	mm**	inches	mm	inches	mm	inches	mm
1/4	6.5	0.128	3.25	0.134	3.40	0.138	3.51
5/16	8	0.160	4.06	0.167	4.24	0.172	4.37
3/8	9.5	0.192	4.88	0.199	5.05	0.206	5.23
7/16	11	0.224	5.69	0.232	5.89	0.241	6.12
1/2	13	0.256	6.50	0.265	6.73	0.275	6.99
9/16	14.5	0.288	7.32	0.298	7.57	0.309	7.85
5/8	16	0.320	8.13	0.331	8.41	0.344	8.74
3/4	19	0.384	9.75	0.398	10.11	0.413	10.49
7/8	22	0.448	11.38	0.464	11.79	0.481	12.22
1	26	0.513	13.03	0.530	13.46	0.550	13.97
1 1/8	29	0.577	14.66	0.596	15.14	0.619	15.72
1 1/4	32	0.641	16.28	0.663	16.84	0.688	17.48
1 3/8	35	0.705	17.91	0.729	18.52	0.756	19.20
1 1/2	38	0.769	19.53	0.795	20.19	0.825	20.96
1 5/8	42	0.833	21.16	0.861	21.87	0.894	22.71
1 3/4	45	0.897	22.78	0.928	23.57	0.963	24.46
1 7/8	48	0.961	24.41	0.994	25.25	1.031	26.19
2	52	1.025	26.04	1.060	26.92	1.100	27.94
2 1/8	54	1.089	27.66	1.126	28.60	1.169	29.69
2 1/4	58	1.153	29.29	1.193	30.30	1.238	31.45
2 3/8	60	1.217	30.91	1.259	31.98	1.306	33.17
2 1/2	64	1.281	32.54	1.325	33.66	1.375	34.93
2 5/8	67	1.345	34.16	1.391	35.33	1.444	36.68
2 3/4	71	1.409	35.79	1.458	37.03	1.513	38.43
2 7/8	74	1.473	37.41	1.524	38.71	1.581	40.16
3	77	1.537	39.04	1.590	40.39	1.650	41.91
3 1/8	80	1.602	40.69	1.656	42.06	1.719	43.66
3 1/4	83	1.666	42.32	1.723	43.76	1.788	45.42
3 3/8	86	1.730	43.94	1.789	45.44	1.856	47.14
3 1/2	90	1.794	45.57	1.855	47.12	1.925	48.90
3 3/4	96	1.922	48.82	1.988	50.50	2.063	52.40
4	103	2.050	52.07	2.120	53.85	2.200	55.88
4 1/4	109	2.178	55.32	2.253	57.23	2.338	59.39
4 1/2	115	2.306	58.57	2.385	60.58	2.475	62.87
4 3/4	122	2.434	61.82	2.518	63.96	2.613	66.37
5	128	2.563	65.10	2.650	67.31	2.750	69.85
5 1/4	135	2.691	68.35	2.783	70.69	2.888	73.36
5 1/2	141	2.819	71.60	2.915	74.04	3.025	76.84
5 3/4	148	2.947	74.85	3.048	77.42	3.163	80.34
6	154	3.075	78.11	3.180	80.77	3.300	83.82

* Values given are applicable to grooves in sheaves and drums; they are not generally suitable for pitch design since this may involve other factors.

**Not a precise conversion; for information only.

Further, the dimensions do not apply to traction-type elevators; in this circumstance, drum-and sheave-groove tolerances should conform to the elevator manufacturer's specifications.

Modern drum design embraces extensive considerations beyond the scope of this publication. It should also be noted that drum grooves are now produced with a number of oversize dimensions and pitches applicable to certain service requirements.

If the fleet angle (Fig. 39) is large, it may be necessary to accept a smaller arc of contact at the throat; 130° for example instead of 150°. This is done to avoid scrubbing the rope on the flange of the sheave.

As previously noted, the groove size is evaluated on the basis of how the gauge fits the groove. Daylight under the gauge is not tolerable when using the worn groove gauge. If a full over-size gauge is used, some daylight may be acceptable, but this really must be judged by relating the measurement to the *actual* size of the rope.

For new rope, extra caution should be observed as to its fit in the groove. Most ropes become smaller in diameter immediately after being placed in service. As a result, they would operate satisfactorily in a "worn" groove; one that was gauged OK by the "worn" groove gauge. Nonetheless, in some cases, a rope may not "pull down," and if this happens, abnormal wear may occur.

It is important to remember that a tight groove not only pinches and damages the rope but that the pinching prevents the necessary adjustment of the wires and strands. On the other hand, a groove that is too large will not provide sufficient support; in this case, the rope will flatten and thereby restrict the free sliding action of the wires and strands.

The size of the groove is not the only critical item to be examined closely. The *condition* of the groove is also an important factor. The groove should be smooth. If the groove is corrugated then it must be remachined or, if it is corrugated too deeply, the sheave, roller or drum must be replaced. If replacement is indicated, a larger sheave or drum and/or a more wear resistant material should be considered.

Groove examination should also concern itself with *how the groove is wearing*. If the rope rubbing against one flange causes the groove to wear off-center, the reeving alignment must be checked and corrected.

When checking the grooves, the bearings of the sheaves and rollers should also be examined. They should turn easily. If not, each bearing must be serviced or replaced. "Wobble" in the sheave—from broken or worn bearings—is not acceptable. Bad bearings will set up vibrations in the wire rope that can cause rapid deterioration unless the condition is remedied. Bad bearings also increase the force on the rope that is needed to move a given load, since friction forces will be greatly increased.

Sheaves with broken flanges may allow the rope to jump from the sheave and become fouled in the machinery. Sheaves with broken flanges must be replaced immediately.

A sheave or drum with a flat spot can induce a "whip" into the line. This whip, or wave may travel until it is reaches the end termination, at which point the rope is subjected to vibratory fatigue stresses. This condition accelerates the fatigue breakage of wires. Sometimes the reeving is such that the whip or wave is damped by a sheave or drum. In these circumstances, the whipping will cause wire breaks along the crowns of the strands. Obviously, sheaves or drums that induce vibrations of this type should be repaired or replaced.

In addition to the items discussed, inspection should also focus on any and all conditions that could cause abnormal or accelerated wear and eventual damage to the wire rope.

For example, plain-face (smooth) drums can develop grooves or rope impressions that will prevent the rope from winding properly. Wear is greatest at the pickup point when the machine is accelerating. If this happens, the surface should be repaired by machining or replaced. The winding should be checked to make sure that the rope is winding "thread wound" (Fig. 33).

Excessive wear in grooved drums should be checked for variations either in the depth or pitch of the grooves.

No matter what type of drum is in use, excessive drum wear will result in poor spooling and rope deterioration. This condition will accelerate rapidly when winding in multiple layers.

STRENGTH LOSS OF WIRE ROPE OVER STATIONARY SHEAVES OR PINS

Rope breaking strength is determined in a standard test wherein fittings are attached to the ends of the rope and the rope is pulled in a straight line. If, however, the rope passes over a curved surface (such as a sheave or pin) its strength "is decreased." The amount of such reduction will depend on the severity of the bend as expressed by the D/d ratio. A rope bent around a pin of its own diameter will have only 50% of the strength attributed to it in the standard test. This is called "50% efficiency" (Fig. 38). Even at D/d ratios of 40, there may be a loss of up to 5%. At smaller D/d ratios, the loss in strength increases rapidly.

The angle of bend need not be 180°, 90°, or even 45°; relatively small bends can cause loss of strength.

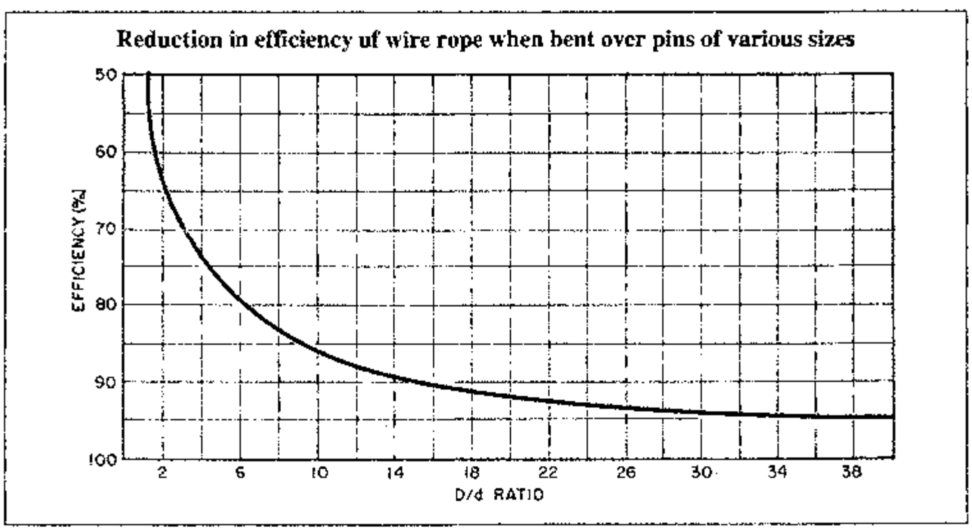


Figure 38 Derived from standard test data, this curve relates rope strength efficiency to various D/d ratios. The curve is based on static loads only.

It is a weighted average of 458 tests over pins and thimbles, on 6 x 19 and 6 x 36 classification ropes, fiber core and IWRC, regular and lang lay. Technically, efficiency variations can be expected for specific rope constructions and wire manufacturing practices. To obtain data for the specific wire rope purchased it is recommended that tests be conducted.

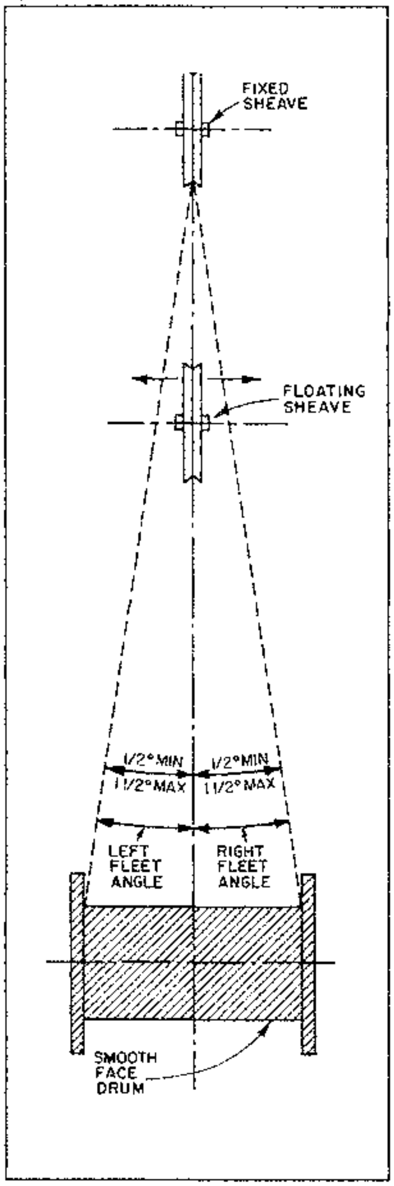


Figure 39. This illustration of wire rope running from a fixed sheave, over a floating sheave, and then onto a smooth drum, graphically defines the *fleet angle*.

FLEET ANGLE

Uniform winding on a smooth faced drum is closely related to the D/d ratio, the speed of rotation, the load on the rope, and the fleet angle. Of all these factors, the one that exerts perhaps the greatest influence on winding characteristics is the fleet angle.

The schematic drawing (Fig. 39) shows an installation where the wire rope runs from a fixed sheave, over a floating sheave, and then onto the surface of a smooth drum. The fleet angle (Fig. 39) may be defined as the included angle between two lines; one line drawn through the middle of the fixed sheave and the drum—and perpendicular to the axis of the drum and a second line drawn from the flange of the drum to the center of the groove in the fixed sheave. (The drum flange represents the farthest position to which the rope can travel across the drum.) There are left and right fleet angles and they may be different values.

It is necessary to restrict the fleet angle on installations where wire rope passes over the lead or fixed sheave and onto a drum. For optimum efficiency and service characteristics, the angle should not exceed 1-1/2° for a smooth drum, or 2° for a grooved drum. Fleet angles larger than these suggested limits can cause such problems as bad winding on smooth drums, and the rope rubbing against the flanges of the sheave. Larger angles also create situations where there is excessive scrubbing and abrasion of the rope on the drum. Conversely, small fleet angles—less than 1/2°—should also be avoided since too small an angle will cause the rope to pile up at the flange of the drum.

FACTORS AFFECTING THE SELECTION OF WIRE ROPE

The key to choosing the rope best suited for the job is making an accurate review of several important requirements. Correct appraisal of the following will simplify the selection process:

1) *Required minimum breaking force*
2) *Resistance to bending fatigue*
3) *Resistance to vibrational fatigue*
4) *Resistance to abrasion*
5) *Resistance to crushing*

It is essentially impossible for any single rope to have high values in all of the above requirements. The rule, in fact, seems to be that a high rating in one almost always means lower ratings in others. The first task is to make a careful analysis of the job requirements, establishing priorities among these requirements, and then selecting the optimum rope on a trade-off basis. This will provide the best possible balance by sacrificing the less essential factors in order to obtain maximum benefits from the more important factors.

Following, are brief explanations of the five factors previously listed:

1) *Required minimum breaking force*

It has been noted that wire rope is a machine—a fairly complex device that transmits and modifies force and motion. Thus, the very first consideration in choosing a "machine," is to determine the potential work load. Stated in terms of wire rope, this means establishing the actual load. To this known dead weight, there must be added those loads that are caused by abrupt starts (acceleration), sudden stops (deceleration) , shock loads, high speeds and friction of sheave bearings. Another item in this equation is the loss of efficiency that occurs when the rope bends over sheaves. All of these factors must be summed up in order to determine the true total load.

For any operation, the total load is multiplied by a required design factor to determine the value which the minimum breaking force of the rope must meet or exceed. Standards organizations and regulatory bodies typically establish minimum design factors. The user must be aware of the design factors specified for their applications and select wire ropes accordingly. (A further discussion of *Design Factors* can be found on p. 93)

2) *Resistance to bending fatigue*

To describe this, a close analogy can be made with a paper clip. While most of us cannot pull a paper clip in two, if repeatedly bent back and forth at one point, it will eventually break. The reason for this is metal fatigue. To some degree, the same thing happens when a wire rope bends around sheaves, drums, and rollers. The sharper—or more acute—the bend, the quicker the fatigue occurs. Increased rope speed and/or reverse bends may also accelerate fatigue rates. As for the rope, with all other rope characteristics being equal, the greater the number of outer wires in each strand, the greater the resistance of the rope to bending fatigue.

3) *Resistance to vibrational fatigue*

Vibration, from whatever source, sends shock waves through the rope. These waves are a form of energy that must be absorbed at some point. This point may appear at various places—the end attachment, the tangent where the rope contacts the sheave, or at any other place where the waves are damped and the energy absorbed.

In the normal operation of a machine or hoist, wire ropes develop a wave action that can be from a low frequency to a sharp, high frequency cycle. A good example of this is found in shaft hoists. When the cage is just starting up, the rope has a very slow swing within the shaft. But, by the time the cage reaches the top of the shaft, the initially low frequency has become a high frequency vibration. The result is fatigue and eventual breakage of the wires at the attachment point to the cage.

Another type of vibrational fatigue is found in operations where there is cyclic loading. Such loadings would be found, for example, in the boom suspension system of draglines. Here, the energy is absorbed at the end fittings of the pendants or at the tangent point where the rope contacts the sheave.

4) *Resistance to abrasion*

Abrasion is one of the most common destructive conditions to which wire rope is exposed. It will occur whenever a rope rubs against, or is dragged through, any soil or other material. It happens whenever a rope passes around a sheave or drum. And, it takes place internally within the rope whenever it is loaded or bent. Abrasive action weakens the rope by removing metal from wires, both inside and outside the rope.

When excessive wear occurs in a rope application, the problem could be caused by faulty sheave alignment, incorrect sheave groove contour, an inappropriate fleet angle, or improper drum winding. However, there may be other causes. If none of these common conditions are found to be causative factors, the solution may be to change to a more suitable rope construction. Remember that ropes with *larger outer wires are more abrasion resistant than ropes with smaller outer wires and lang lay ropes are more abrasion resistant than regular lay ropes. (See p. 10 - 11 for a discussion on lang-lay rope.)*

5) *Resistance to crushing*

Rope crushing typically occurs in multiple layer drum spooling at the change of layer points and at the cross over points. At the change of layer point, the rope can be wedged between the preceeding wrap on the drum and the drum flange. This wedging creates side pressure that can distort the rope's circular shape. At the cross over points, the rope goes from being supported by two wraps of rope on the layer below to being supported at a single contact point. This doubles the contact pressure and can crush the rope. Under very high loading conditions, the rope may crush or flatten around the entire circumference of the drum.

Items that generally increase a rope's resistance to crushing are ropes with fewer outer strands, larger outer wires in strands, IWRCs instead of FC, regular lay instead of lang lay, compaction of strands and compaction of rope.

THE "X-CHART"—ABRASION RESISTANCE VS BENDING FATIGUE RESISTANCE

Two compelling factors that govern most rope selection decisions are: *abrasion resistance, and resistance to bending fatigue.* Striking a proper balance with respect to these two important characteristics demands careful consideration. A graphic presentation of this comparison of qualities, between the most widely used rope constructions and others, is given by means of the *X-chart* (Fig. 40).

Referring to this chart when selecting a rope, the mid-point (at the X) comes closest to an even balance between abrasion resistance and resistance to bending fatigue. Reading up or down along either leg of the X, the inverse relationship becomes more apparent as one quality increases and the other decreases.

The term *flexibility* is frequently thought of as being synonymous with *resistance to bending fatigue*. This is not true. Flexibility refers to the capability of *flexing* or *bending*. While a high degree of fatigue resistance may sometimes accompany the flexibility characteristic, it does not necessarily follow that this is so. A fiber core rope, for example , is more *flexible* than an IWRC rope. Yet, when the IWRC rope is bent around sheaves at relatively high loads, it will usually perform better than the more flexible fiber core rope. The reason for this lies in the ability of IWRC rope to better support the outer strands, retain its roundness and maintain freedom of internal movement. Under the same conditions, a fiber core rope will flatten and inhibit free internal adjustment, thereby reducing fatigue life.

As with all engineering design problems, feasible solutions demand compromise to some degree. At times, it becomes necessary to settle for less than optimum resistance to abrasion in order to obtain maximum fatigue resistance, the latter being a more important requirement for the given job. A typical example of this kind of trade-off would be in selecting a highly fatigue resistant rope on an overhead crane. Conversely, in a haulage installation, a rope with greater resistance to abrasion would be chosen despite the fact that such ropes are markedly less fatigue resistant. Ultimately, what is sought is an efficient, economical solution, hence whatever the compromise, it should assist in achieving this goal.

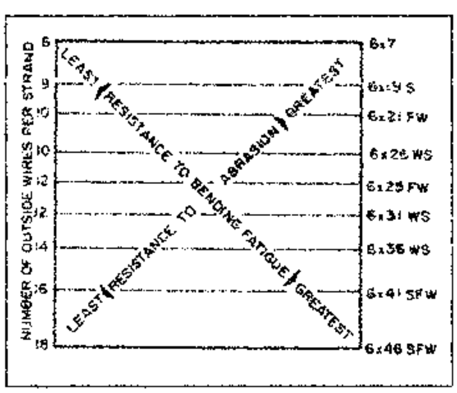


Figure 40. The wire rope industry refers to this as the X-chart. It serves to illustrate the inverse relationship between abrasion resistance and resistance to bending fatigue in a number of the commonly used wire rope constructions.

GUIDELINES FOR MAKING REQUIRED INSPECTIONS FOR ANY WIRE ROPE USE AND APPLICATION

When in use, all wire ropes degrade and lose strength, regardless of the application. Not conducting proper wire rope inspections can lead to dangerous and costly situations. Properly performed inspections are, therefore, an essential part of the safe and efficient use of every wire rope.

This is precisely why industry safety standards developed and published by the Occupational Safety and Health Administration (OSHA), American National Standards Institute (ANSI), American Society of Mechanical Engineers (ASME) and various other industry and governmental organizations require frequent, periodic inspections with permanent records. The rope user is responsible for using the proper standard for inspection.

The following information will be a useful aid in planning and making an inspection program for any wire rope installation or usage.

HOW TO INSPECT

An inspection program is an integral part of every wire rope application and requires a specific schedule, trained and qualified inspectors, the criteria applicable to the usage, and permanent records.

There are also tools and techniques the inspector must have in order to evaluate a rope's condition, and the knowledge to determine if a rope can continue to perform the work required of the installation.

A basic understanding of how wire ropes and wire rope slings are designed and manufactured, and how they operate, is also useful. The inspector must be able to recognize specific evidence of damage and degradation in them.

REQUIREMENTS FOR INSPECTION

Inspection requires certain tools, such as a micrometer, calipers, steel tape measure, groove gauges and forms for recording data.

The specific criteria published in industry standards and governmental regulations are also necessary.

The inspector must also have access to the entire rope length and ability to see the rope's condition close-up.

Specific aspects of wire rope inspection are discussed on the following pages including diameter, broken wires, internal rope inspection, etc.

ACCESS FOR INSPECTION

There are two types of inspections, and access requirements are different for each. Daily, work shift, or frequent inspections may not require examining the entire length of a rope. These inspections are visual observations and are concerned with discovering gross damage and potential problems. Periodic inspections, where permanent records are normally mandated by OSHA, ASME and other regulatory agencies, require more stringent attention to specific details through the entire length of the rope - including diameter, lay measurement, broken wire counts, evidence of rope core failure, abuse and wear.

Wear occurs throughout the length of any wire rope, especially running wire ropes that move on and off drums and sheaves. Even supporting or standing ropes undergo stress and vibration throughout the length. Both running and standing ropes require proper inspection, each with specific requirements.

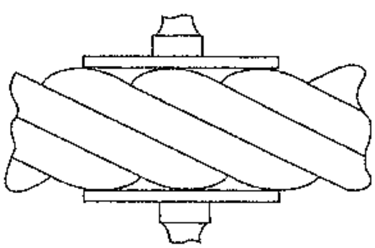
The rope must be seen up close, which requires adequate light and good vision; this may include the use of artificial lighting and magnification. The inspector must also be able to physically touch or perform a hands on examination of the rope. In most applications, a thorough inspection is made when the rope is relaxed or under minimal tension. However, non-destructive testing (NDT) may be used where the rope cannot be relaxed.

The total rope system must be inspected, since the movement and condition of drums, sheaves, fairleads, equalizer sheaves, and other components have a direct bearing on wear and ability of a rope to perform properly.

End attachments are critical points of stress, because these are where the load is transferred to other components as tension is applied and released in the rope. The first wire breaks may occur at an end termination.

Rope degradation may not always be readily visible. Broken wires, wear, and corrosion may be hidden by lubricant, dirt or other foreign material on the rope. Sections of rope must be wiped clean with a cloth or wire brushed in order to count broken wires or to view wear or corrosion.

Normal wear and degradation are expected to occur in areas where the rope bends frequently, spools on a drum, at equalizer sheaves, or at end terminations. These areas endure greater stress and should be checked completely and frequently. Another area of concern is core integrity. There are specific indicators of interior rope damage such as loss of rope diameter, evidence of valley breaks or breaks against the core that result in high or protruding wires, and rust or corrosion products in the rope valleys. Core integrity can only be verified by prying open the rope with awls or picks. However, this is usually a last resort to substantiate a decision to condemn and remove a rope from service and should only be done by a qualified person, as the inspection may damage the rope and make it unusable.



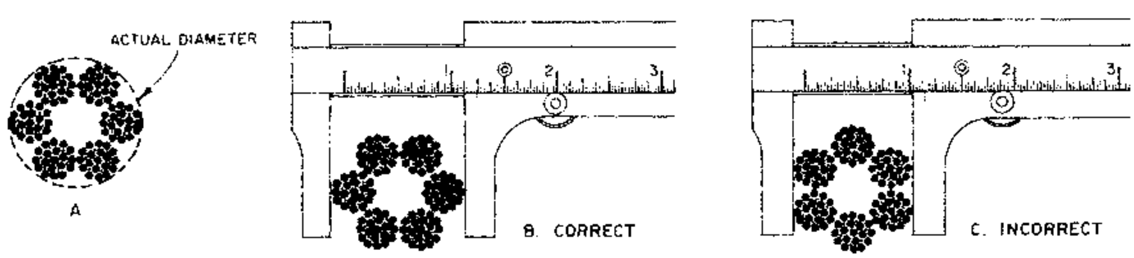
Proper method of measuring ropes with odd number of outer strands, using caliper with plates.

ROPE DIAMETER

Diameter meaurements give the inspector indicators of wear and internal degradation in a wire rope. Thorough inspections require diameter measurements at several places in the rope's length and in areas that endure greater stress.

Generally, ropes are manufactured larger than nominal diameter. When placed in service for the first time, diameter can reduce slightly. Therefore, the initial measurement of a rope's diameter should be made after the rope's initial loading or

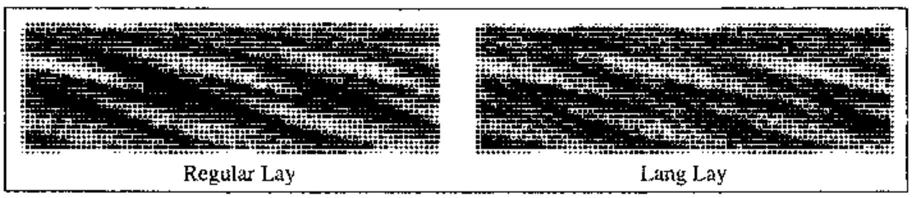
How to measure (or caliper) a wire rope correctly. Since the "true" diameter (A) lies within the circumscribed circle, always measure the larger dimension (B).



breaking in period (see pg 25-26 for more information). That is the measurement to be recorded as the initial diameter.

The actual rope diameter must be measured. This is defined as the diameter of the circumscribing circle. (ie, its largest cross sectional dimension) To insure accuracy this measurement should be made with a wire rope caliper using the correct method (b) shown on the facing page. Special techniques and equipment must be employed for measuring ropes with an odd number of outer strands. (eg, circumferential tapes, calipers with plates – see illustration on facing page).

Wear occurring at the crowns of outer wires is normal. Many standards state a rope must be removed from service when its actual diameter is reduced to 95% of the nominal diameter. The accompanying photos show examples of heavy normal wear on both regular and lang lay wire ropes.



This picture simulates 6 x 25 fw construction wire ropes with surface wear (only) of 1/3 the outer wire diameter.

Plastic enhanced ropes (impregnated or filled) require careful measurements. It is essential to measure the metal, not plastic on the exterior of the rope. Exterior measurement cannot be used to determine diameter reductions of the wire rope in plastic coated (jacketed) ropes.

Rope core deterioration usually results in a reduction of the rope's diameter, making careful measurement important. Although the core provides less than 10% of the rope's strength (on standard six or eight strand IWRC ropes), that loss of strength may not be the primary concern. Deterioration of the core leads to increased stress and broken wires in the outer strands of the rope. These broken wires are usually valley breaks which can be more difficult to detect.

BROKEN WIRES

Broken wires are another primary indicator of rope degradation, and remaining useful life. The accompanying table shows allowable wire breaks in typical installations. These broken wire removal criteria apply to wire rope operating on steel sheaves and drums. The user shall contact the sheave, drum, or equipment manufacturer or a qualified person for broken wire removal criteria for wire ropes operating on sheaves and drums made of material other than steel. If no other information is available, the standard broken wire removal criteria should be used. However, since the use of plastic sheaves may cause internal wire breakage, the inspector must pay particular attention to evidence of valley breaks or breaks against the core and corrosion in the rope valleys.

TABLE 14 WHEN TO REPLACE WIRE ROPE-BASED ON NUMBER OF BROKEN WIRES*

		Running Ropes			Standing Ropes	
		No. Broken Wires in Standard Ropes		No. Broken Wires In Rotation Resistant Ropes	No. Broken Wires	
Standard	Name	In all strands in one Rope Lay	In one strand in one Rope Lay		In one Rope Lay	At End Connections
ASME/B30.2	Overhead & Gantry Cranes	12**	4	--	--	--
ASME/B30.4	Portal, Tower & Pillar Cranes	6**	3	4 in all strands in one rope lay or 2 in one strand in one rope lay	--	--
ASME/B30.5	Crawler, Locomotive & Truck Cranes	6**	3	2 in 6 rope diameters or 4 in 30 rope diameters	3	2
ASME/B30.6	Derricks	6**	3	--	3	2
ASME/B30.7	Base Mounted Drum Hoists	6**	3	--	3	2
ASME/B30.8	Floating Cranes & Derricks	6**	3	--	3	2
ASME/B30.16	Overhead Hoists	12**	4	2 in 6 rope diameters or 4 in 30 rope diameters	--	--
ANSI/A10.4	Personnel Hoists	6**	3	--	2**	2

**For rope operating on steel sheaves and drums. Contact the sheave, drum, equipment manufacturer or a qualified person for removal criteria for wire ropes operating on sheaves and drum made of material other than steel.
**Also remove for 1 valley break (at strand-to-strand contact point) or one protruding or looped wire broken at strand-to-core contact point.

Wire breaks generally are seen in two locations on a rope; at the crowns of outer strands and in the valleys between outer strands.

Crown Wire Breaks

Valley Wire Breaks

Crown wire breaks usually are due to normal wear and typically have square ends. Valley breaks may indicate an abnormal condition, such as loss of core support, small sheave grooves or deterioration from unusually heavy rope loading.

When a wire has broken from excessive loading or a tensile overload, the ends of the wire will be pulled or necked down in diameter on each side of the break, in contrast to the typical square ends of crown wire breaks. In normal service, the wire breaks will exhibit characteristics of both axial loading and fatigue.

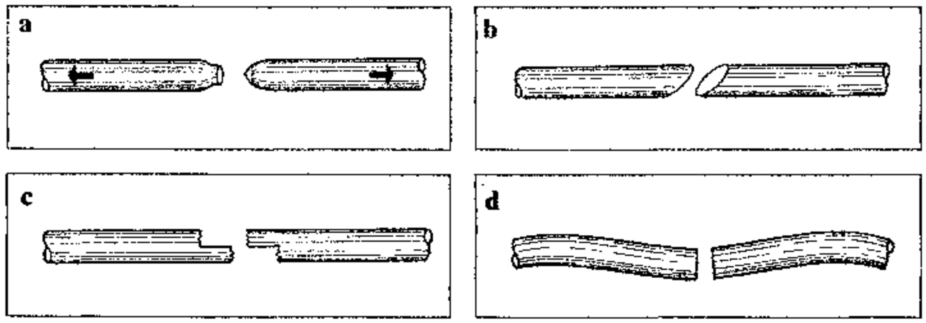
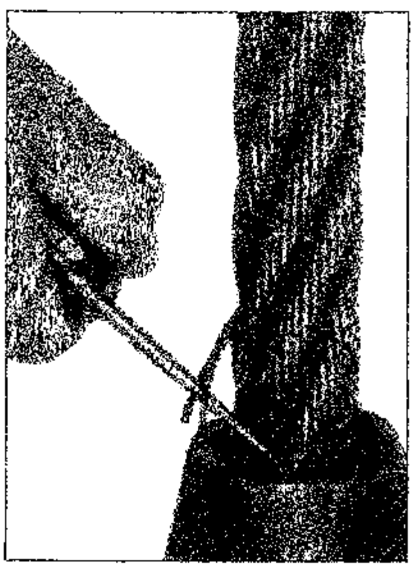


Figure 43. A wire broken under a tensile load that exceeds its strength is recognized by the "cup and cone" configuration at the fracture point (a). The *necking down* of the wire at this point shows that failure occurred while the wire retained its ductility. Shear-tensile fracture (b), usually exhibiting an angular flat plane failure surface, occurs in wire subjected to a combination of transverse and axial loads. Fatigue breaks are usually characterized by squared-off ends perpendicular to the wire either straight across or Z-shaped (c&d).



Wire Breaks at End Termination

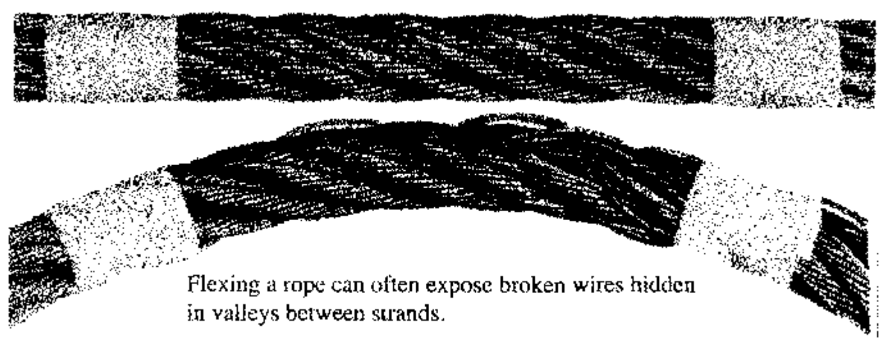
TYPES OF WIRE BREAKS

As a wire rope moves over sheaves and drums, each strand and each wire in every strand moves and adjusts. Bending the rope or observing it moving slowly over a sheave can help the inspector find broken wires.

Once wire breaks appear, their numbers will increase if the rope continues in service.

Valley and strand-to-core contact point breaks are difficult to detect in a rope and must be taken very seriously. These types of wire breaks are indicative of conditions that result in internal degradation occurring at a faster rate than external degradation.

Wire breaks at rope terminations are also indicators of rope degradation. A single broken wire at a termination is usually reason to question continued use of a rope; more than one break is usually sufficient reason to remove the rope from service.



Flexing a rope can often expose broken wires hidden in valleys between strands.

HOW TO COUNT BROKEN WIRES

Criteria for wire breaks, provided in Table 14 have been published by OSHA, ASME and other industry and governmental organizations for specific applications. The criteria must be applicable for the wire rope being inspected.

Allowable broken wires are stated either in relation to the rope's lay or multiples of rope diameter. Rope lay is one of the characteristics of wire rope that needs to be understood by a qualified inspector. Many industry standards and government regulations base the broken wire removal criteria on the number of wire breaks in a specified length or distance called a rope lay. Each wire rope has its own particular lay length. Just as the initial rope diameter was not determined until the rope had been installed, loaded and, ideally, broken in, the same practice should be followed with regard to the initial rope lay. The initial rope lay measurement should be recorded along with the initial rope diameter measurement.

To measure one rope lay, mark a spot on one strand, then with a finger, trace that strand along one complete wrap around the rope, then make another mark on the same strand. This distance beween the marks is one rope lay.

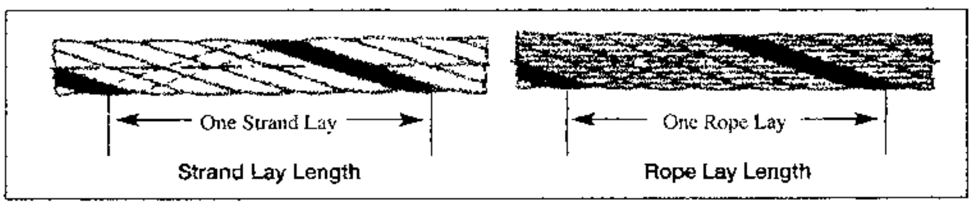
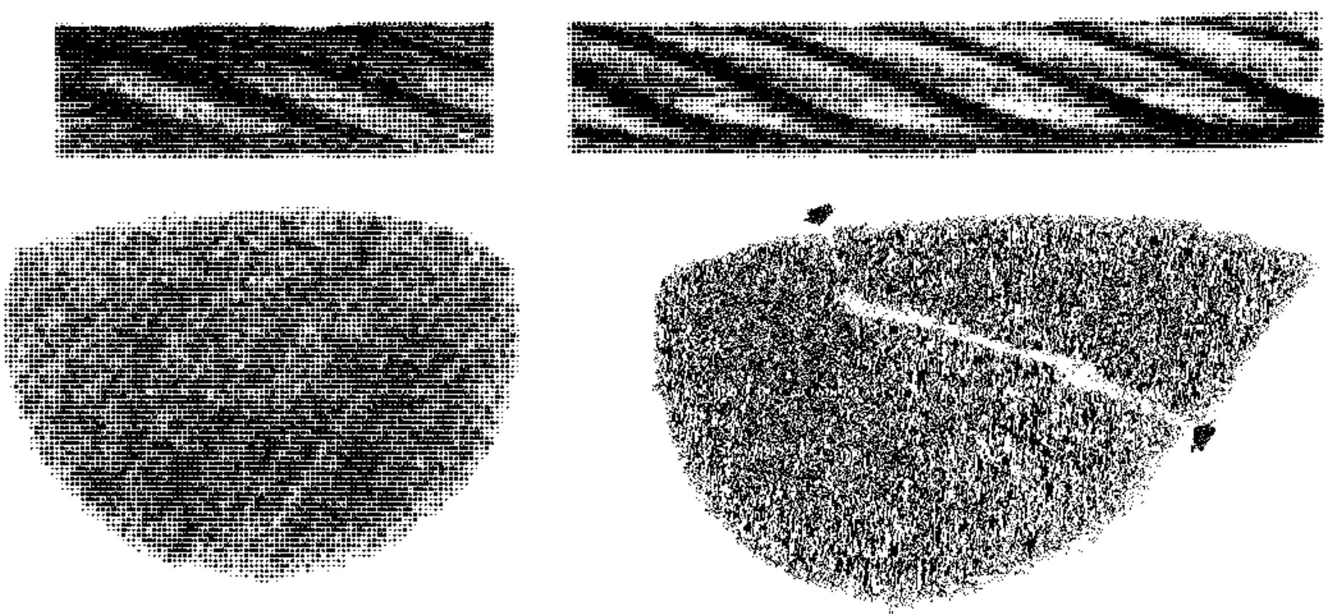


Figure 42. These plan views and cross sections show the effects of abrasion and peening on wire rope. Note that a crack has formed as a result of heavy peening.

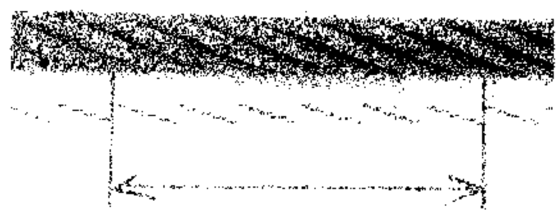


abrasion

peening

It is possible to measure rope lay by placing a sheet of paper on the rope and stroking the paper with the side of a pencil. The image can be used to measure the rope's lay length. Count the number of outer strands in the rope, mark a starting point on one strand impression; count the same number of impressions as the number of outer strands; and make another mark. The lay length is the distance between the marks made on the image.

By maintaining records of lay measurements at all inspections, a comparison can be made to detect changes in lay length that provides evidence of degradation. Any significant change in the rope's lay length between subsequent inspections is usually an indication that degradation has occured and a more careful inspection is warranted. To utilize this inspection and evaluation technique, the lay measurement comparisons must be made of impressions or measurements of the same section of rope on subsequent inspections.



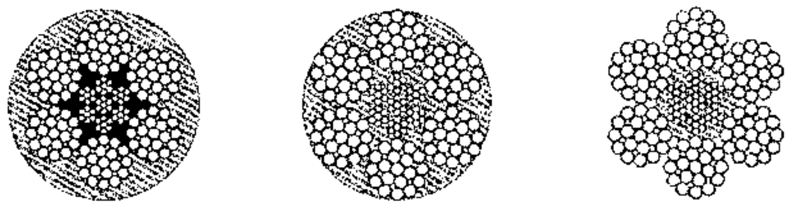
SPECIALTY ROPES

Round strand wire rope designs that have been in use for more than a century have been replaced in numerous applications by several enhanced rope constructions. These include compacted ropes, compacted strand ropes, plastic filled ropes, plastic coated ropes, rotation resistant ropes, shaped-strand ropes, and coreless ropes.

The same inspection techniques apply to all ropes. The diameter, broken wires per specified interval, and change of lay length are important. Specialty ropes can pose challenges in determining operating limits and the necessity to remove from service. The rope manufacturer should be contacted for any specific instructions or recommendations.

PLASTIC ENHANCED ROPES

Wire breaks can occur in all plastic enhanced ropes, however in the case where the plastic inhibits visual inspection, normal broken wire criteria cannot always be applied. In plastic coated wire ropes diameter reduction can be a better indicator of rope degradation than visible broken wires. Removal criteria for these ropes are normally provided by the equipment manufacturer.
In plastic filled ropes and plastic coated IWRC ropes, normal inspection techniques will detect broken wires, but they may be more difficult to find. Since the plastic covering the crown wires of plastic filled ropes is relatively thin and wears away quickly, finding crown wire breaks is similar to standard ropes. Valley breaks are more difficult to detect. If a valley wire break is detected, it is prudent to increase the frequency of inspections and to be conservative in assessing continued use of the rope.



Plastic Coated Wire Rope | Plastic Filled Wire Rope | Plastic Coated IWRC Wire Rope

Plastic Processed Wire Rope Cross Sections.

Corrosion can occur in plastic enhanced ropes, and have the same effect as in standard ropes. Core condition and damage can be detected by diameter reduction and lengthening of lay.

Separation of plastic coating is not necessarily an indicator of rope deterioration, however, it indicates a potential problem, and warrants close observation.

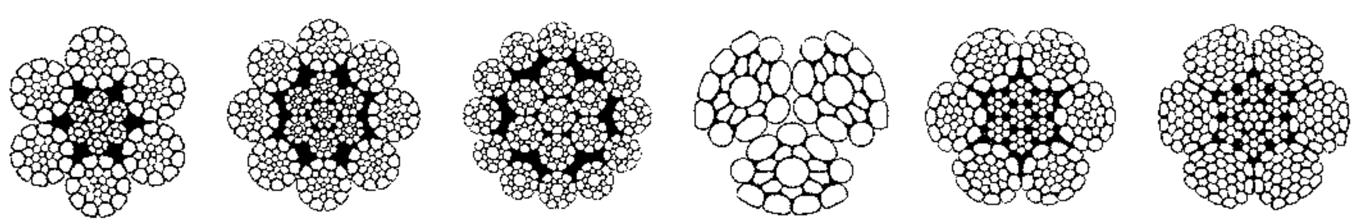
COMPACTED ROPE AND COMPACTED STRAND ROPES

During manufacture, these specialty ropes are drawn through dies and/or swaged to compact the metal content of the rope. Strands may be compacted before the rope is closed, or the entire rope compacted.

When inspecting these ropes follow basic guidelines. Diameter and lay measurement procedures are no different than with standard ropes. It is essential to record a new rope's actual diameter and lay length immediately after installation to establish the base line for comparison at future inspections.

Wire breaks can be more difficult to detect than in standard ropes, because the ends of the break do not always displace or separate. Any suspected wire break should be viewed with a magnifying glass to determine if it is a break. Bending the rope or observing it moving slowly over a sheave helps the inspector detect broken wires.

Due to compaction, the spaces between wires and strands inside a rope are minimized, and lubrication is critical so that sliding and adjusting of wires and strands is not restricted. The inspector should be observant to the lack of or need for lubricant.

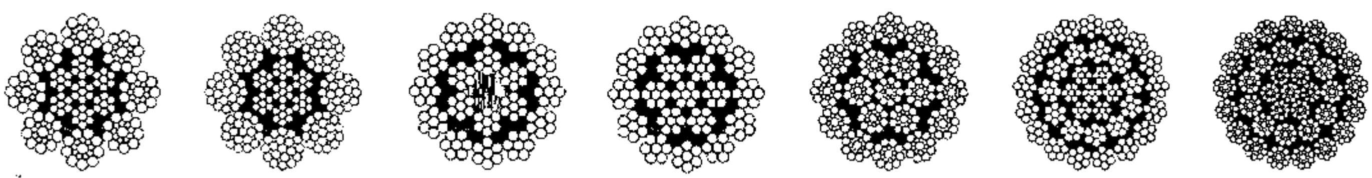


6 x 26 Warrington Seale Compacted Strand IWRC | 8 x 26 Warrington Seale Compacted Strand IWRC | 19 x 19 Seale Compacted Strand | 3 x 19 Seale Compacted (Swaged) | 6 x 26 Warrington Seale Compacted (Swaged) IWRC | 6 x 31 Warrington Seale Compacted (Swaged) IWRC

ROTATION RESISTANT ROPES

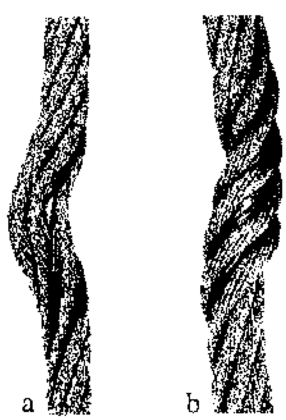
These wire ropes are designed so that the inner strands are laid counter to the outer strands. Under certain operating conditions, this design can result in accelerated internal wear. Careful initial measurements of diameter and lay are essential for comparisons in future inspections.

Inspection procedures are generally the same as other ropes; however, the broken wire removal criterion is more restrictive. (see Table 14)



8 x 19 Seale IWRC | 8 x 25 Filler Wire IWRC | 18 x 7 FC | 19 x 7 | 19 x 19 Seale | 35 x 7 | 35 x 19 Seale

RESULTS OF ABUSE

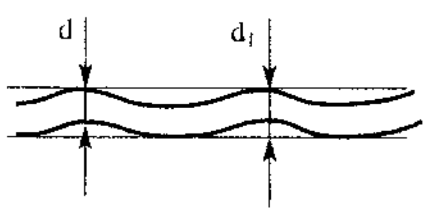


Abuse from handling and poor operating conditions may cause damage and can result in reduced service life of the wire rope. It is important to recognize the effects of these abuses to properly assess rope serviceability.

Kinks (see Figure a&b left) are tightened loops with permanent strand distortion that result from improper handling when a rope is being installed or while in service. A kink happens when a loop is permitted to form and then is pulled down tight, causing permanent distortion of the strands. The damage is irreparable and the kink must be cut out or the entire rope taken out of service.

Doglegs (see Figure 53, pg 79) are permanent bends caused by improper use or handling. If the dogleg is severe, the rope should be removed from service. If the dogleg is minor, (exhibiting no strand distortion) and cannot be observed when the rope is under tension, the area of the minor dogleg should be marked for observation and the rope can remain in service.

Wavy rope occurs when one or more strands are misaligned with the rope body. This results from a variety of causes, including failure to properly seize the end of a rope prior to wedge socket installation; tight sheave grooves; or permitting torque or twist to develop during installation or operation. While not necessarily resulting in loss of strength, this condition may accelerate rope deterioration and requires increased frequency of inspections. Ropes must be removed from service when the height of the wave (d_1) measures more than 33% of the nominal rope diameter above the nominal rope diameter in sections not bending around a sheave or drum or more than 10% of the nominal rope diameter above the nominal rope diameter in sections bending around a sheave or drum.



IWRC or strand core protrusion between outer strands, commonly called bird caging or popped core, usually results from shock loading during operation, but can also be caused by improper handling. The damage is irreparable and the affected area must be cut out or the entire rope taken out of service.

Crushing or flattening of the strands or rope is caused by various factors, including poor spooling on a drum, heavy loading and even poor installation procedures. This can result in broken wires or the accelerated deterioration of the rope.

Abrasion (metal loss) and peening (metal deformation) occur when the rope contacts another metallic or abrasive surface, or from passing over the drum or sheaves. These result in the reduction of diameter and broken wires.

Corrosion is most often the result of a lack of lubrication. It may result in premature fatigue failure of individual wires. It is especially important to inspect ropes at end terminations.

Heat damage comes from any heat source such as welding, fire, power line strikes, or lightning. The damage is irreparable and the affected area must be cut out or the entire rope taken out of service.

Protruding broken wire is a condition where one outer wire is broken at the point of contact with the core of the rope and has worked its way out of the rope structure and protrudes or loops out from the rope structure. The damage is irreparable and the affected area must be cut out or the entire rope taken out of service. There are occasions when a valley break (at strand to strand contact point) will protrude or raise above the surface of the rope. This also is a condition of serious concern and somewhat difficult to differentiate from a wire break at the strand to core contact point. When there are two or more valley breaks in a rope lay the affected area must be cut out or the rope taken out of service.

INSPECTION RECORDS

Periodic inspections require a permanent record of each rope on the equipment. The sample form included in this brochure may be copied and completed by the inspector for the permanent record. This form is designed to provide a road map for recording pertinent data as an inspection proceeds.

Any wire rope manufacturer that is a member of the Wire Rope Technical Board can provide inspection criteria, including recommendations and requirements of OSHA, ASME, ANSI, and other industry and governmental regulations.

Permanent records of inspections are required by OSHA and other governmental regulations, and will be used for reference at the next inspection. These can be kept with the operator and maintenance manuals for the application, or in permanent office files.

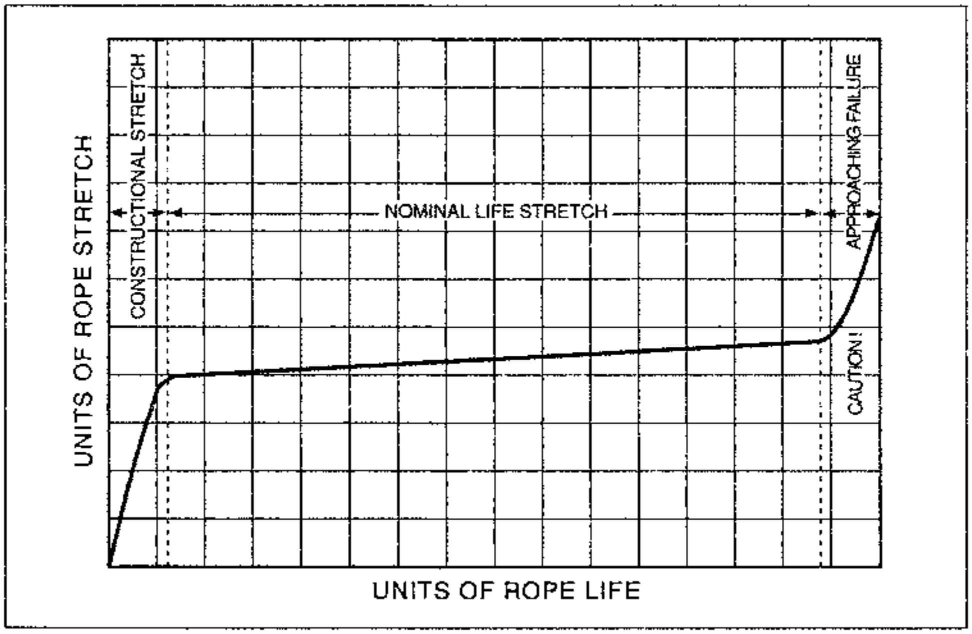


Figure 41. This curve is plotted to show the relationship of wire rope stretch to the various stages of a rope's life.

WIRE ROPE STRETCH

All ropes will stretch when loads are initially applied. For an extended discussion of stretch, see pp. 89-92.

As a rope degrades from wear, fatigue, etc. (excluding accidental damage), continued application of a load of constant magnitude will produce varying amounts of rope stretch. A "stretch" curve plotted for stretch vs. time (Fig. 41) displays three distinct phases:

Phase 1. Initial stretch, during the early (beginning) period of rope service, caused by the rope adjustments to operating conditions (constructional stretch).

Phase 2. Following break-in, there is a long period—the greatest part of the rope's service life—during which a slight increase in stretch takes place over an extended time. This results from normal wear, fatigue, etc. On the plotted curve—stretch vs. time--this portion would almost be a horizontal straight line inclined slightly upward from its initial level.

Phase 3. Thereafter, the stretch occurs at a quicker rate. This means that the rope has reached the point of rapid degradation; a result of prolonged subjection to abrasive wear, fatigue, etc. This second upturn of the curve is a warning indicating that the rope should soon be removed.

TABLE 15 DIAGNOSTIC GUIDE TO COMMON WIRE ROPE DEGRADATION

Mode	Symptoms	Possible Causes
Fatigue	Wire break is transverse--either straight across or Z shape. Broken ends will appear grainy.	Check for rope bent around too small a radius; vibration or whipping; wobbly sheaves; rollers too small; reverse bends; bent shafts; tight grooves; corrosion; small drums & sheaves; incorrect rope construction; improper installation; poor end terminations. (In the absence of other modes of degradation, all rope will eventually fail in fatigue.)
Tension	Wire break reveals a mixture of cup and cone fracture and shear breaks.	Check for overloads; sticky, grabby clutches; jerky conditions; loose bearing on drum; fast starts, fast stops, broken sheave flange; wrong rope size & grade; poor end terminations. Check for too great a strain on rope after factors of degradation have weakened it.
Abrasion	Wire break mainly displays outer wires worn smooth to knife edge thinness. Wire broken by abrasion in combination with another factor will show a combination break.	Check for change in rope or sheave size; change in load; overburden change; frozen or stuck sheaves; soft rollers, sheaves or drums; excessive fleet angle; misalignment of sheaves; kinks; improperly attached fittings; grit & sand; objects imbedded in rope; improper grooving.
Abrasion plus Fatigue	Reduced cross section is broken off square thereby producing a chisel shape.	A long term condition normal to the operating process.
Abrasion plus Tension	Reduced cross section is necked down as in a cup and cone configuration. Tensile break produces a chisel shape.	A long term condition normal to the operating process.
Cut or Gouged or Rongh Wire	Wire ends are pinched down, mashed and/or cut in a rough diagonal shear-like manner.	Check on all above conditions for mechanical abuse, or either abnormal or accidental forces during installation.
Torsion or Twisting	Wire ends show evidence of twist and/or cork-screw effect.	Check on all the above conditions for mechanical abuse, or either abnormal or accidental forces during installation.
Mashing`	Wires are flattened and spread at broken ends.	Check on all the above conditions for mechanical abuse, or either abnormal or accidental forces during installation. (This is a common occurrence on the drum.)

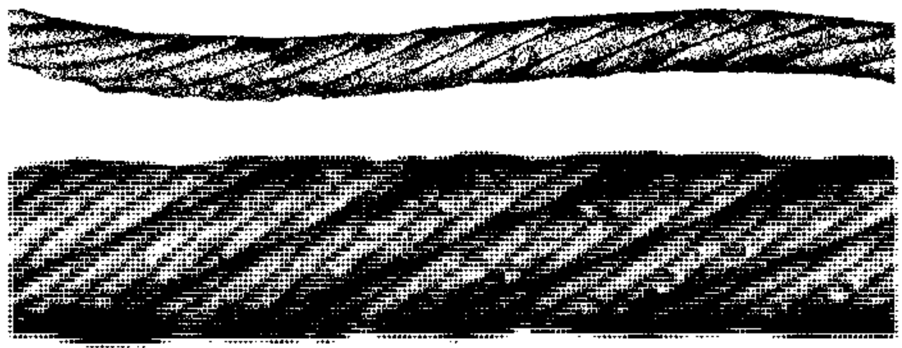


Figure 44A. An outer strand (top) from a 19 x 7 rotation resistant rope shows nicking that occurs between adjacent strands as well as between strands and the inner rope (bottom). Similar nicking patterns occur in other ropes with an IWRC.

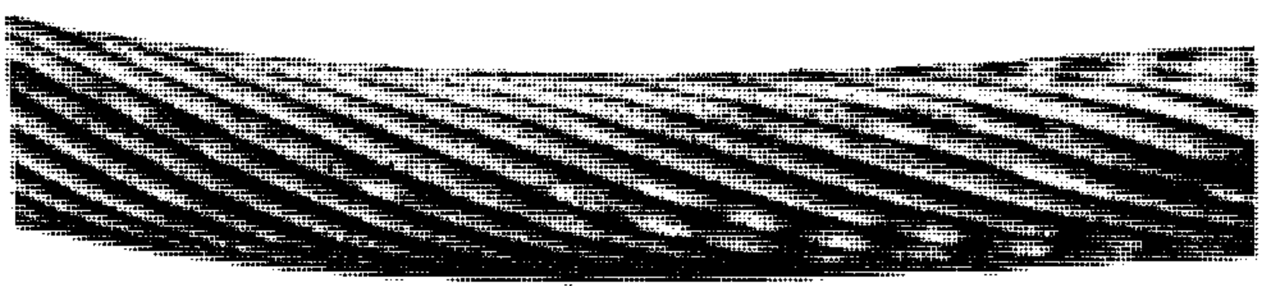


Figure 44B. An outer strand removed from a wire rope that experienced strand-to-strand nicking. This nicking results from adjacent strands rubbing against one another and can be an indication of core failure, operation of the rope under high loads, improper sheave groove contour or small bending radii. Ultimately, this may result in wire breaks in the valleys between the strands.

Figure 45A. A tightly spiralled "pig-tailed" rope; this condition is often the result of the rope being pulled around an object that has a small diameter.

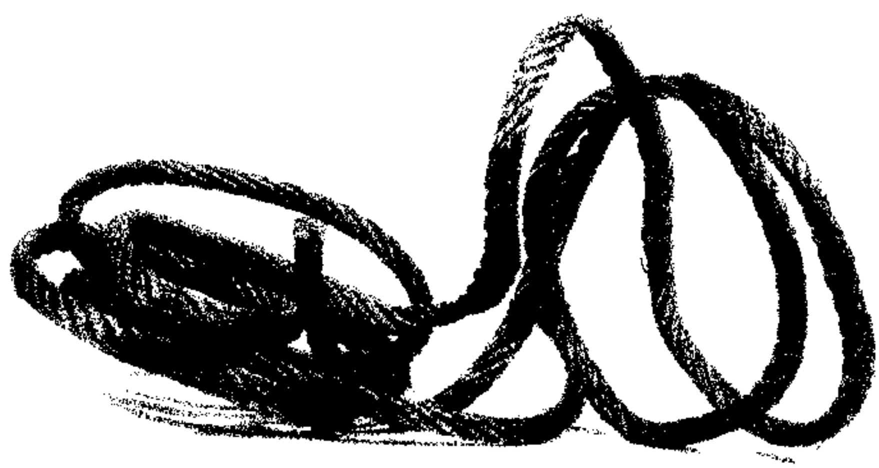


Figure 45B. Drum crushing and spiraling in a winch line. This is caused by the small drums, high loads, and multiple layer uncontrolled winding conditions frequently found on winches.

Figure 46. When a reel has been damaged in transit, it is a safe assumption that there can be irreparable damage to the rope.

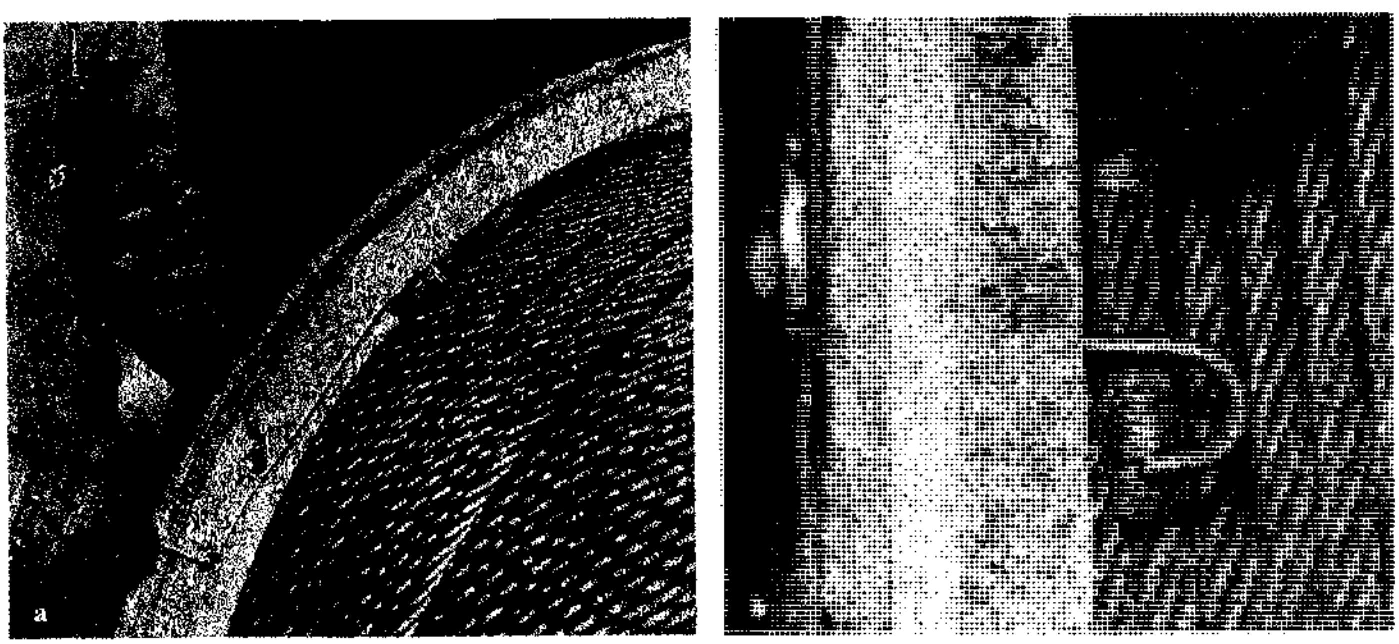


Figure 47. Wire rope abuses during shipment create serious problems. One of the more common causes is improper fastening of rope end to reel, e.g., nailing through the rope end. These photos show two acceptable methods: a) one end of a wire "noose" holds the rope, and the other end is secured to the reel; and b) the rope end is held in place by a J-bolt or U-bolt that can be fixed to a reel.

Figure 48. Wire rope with a high strand. In this condition, one or two strands are worn before adjoining strands. This is caused by improper socketing or seizing, kinks or doglegs. The top illustration (a) is a close view of the concentration of wear, the lower (b) shows how, in a six-strand rope, this recurs in every sixth strand.

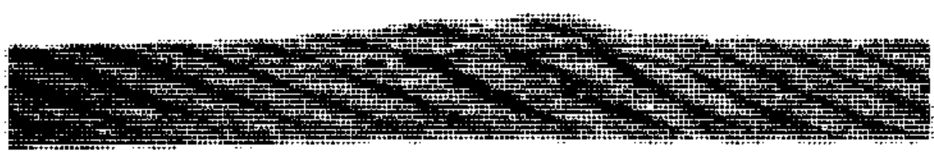


Figure 49. This rope was damaged on the reel by a sharp object.

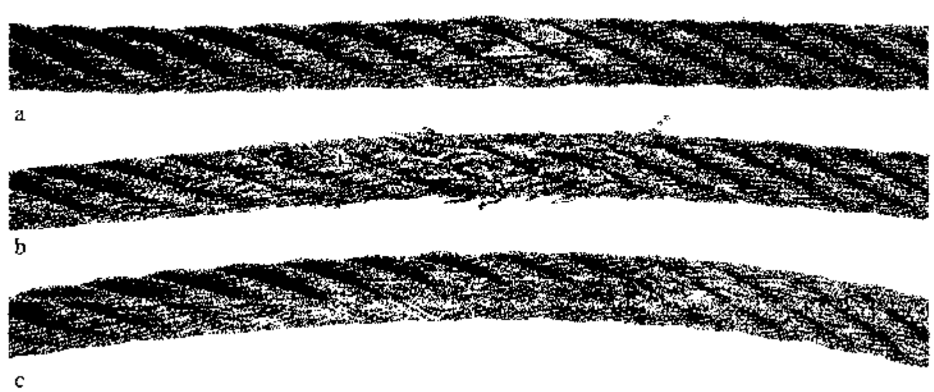


Figure 50. These rope damages—the result of bad drum winding— are referred as: a) layer-to-layer crushing, b) scrubbing at cross-over or flange turnback, and c) layer-to-layer crushing.

Figure 51, The individual wires in this rope have been distorted and displaced from their normal position due to drum crushing.

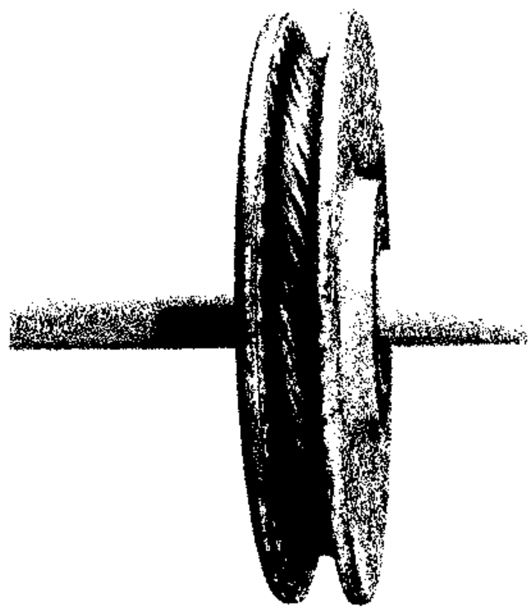


Figure 52. A deeply corrugated sheave.

Figure 53. This rope condition is called a dogleg.

The following conditions (Figs. 54 and 55) are often caused by a sudden release of tension and the resulting rebound of the rope from its loaded condition. The strands and wires are trapped in the position shown and can not return to their original position. These conditions can also result from a build up of twist in the rope.

Figure 54. Improper handling, rope rotation or sudden release of a load can cause a 'popped core'.

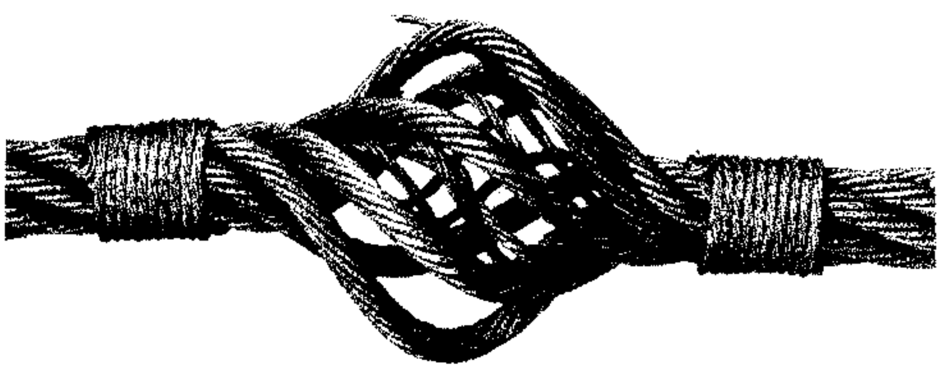


Figure 55. A 'birdcage' resulting from a sudden release of the load causes damage to the rope structure.

Figure 56. 'Snagged wires' can be the result of damage to the rope in service or from unequal adjustment of wire within the rope's strands. This condition can be accentuated by lack of lubrication.

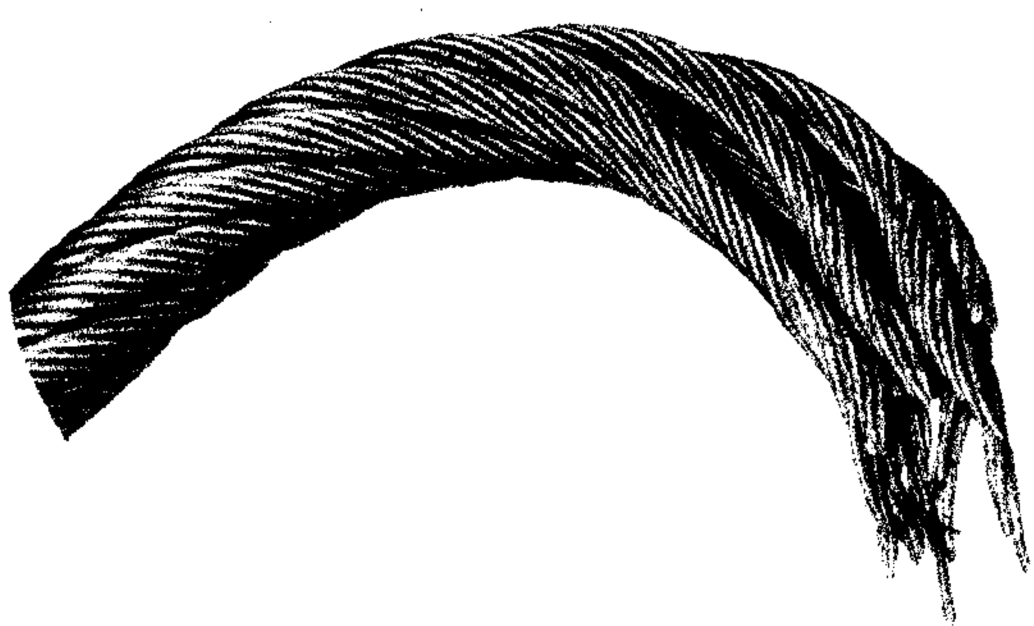


Figure 57. This is an example of a wire rope that has jumped a sheave and failed in tension over a small radius. The deformation is in the shape of a curl—from being bent around the small radius.

Figure 58. This is the appearance of a typical tension break on a test sample broken in a tensile machine Note, not all strands have failed as the load relaxes when the initial few stands and/or the core fail.

Figure 59. This rope was subjected to repeated bending over sheaves while under normal loads. Fatigue breaks in the individual outer wires resulted. The wire breaks are square-end and the majority are found on the crown of the strands.

Figure 60. An example of fatigue fractures in a wire rope that was subjected to heavy loads while over small sheaves. Most wires are breaking in the valleys between the strands. These valley breaks are a result of strand-to-strand nicking. See Figures 44A and B.

Figure 61. A typical example of localized wear. The cumulative effect can be minimized and the rope life extended if a suitable cut-off practice was employed.

ELECTROMAGNETIC TESTING OF WIRE ROPE

Electromagnetic non-destructive testing (NDT) of wire rope can be an extremely valuable tool for the evaluation of the condition of a wire rope. NDT is frequently used on wire ropes used in underground mines, material and passenger tramways, and aerial lifts. The NDT devices in use today are capable of detecting localized faults such as wire breaks and damage and loss of metallic area (LMA). A strip chart can be produced by the device which provides a visual display and location of anomalies from a baseline reading. The rope can then be visually inspected for confirmation and assessment of the actual condition.

It is recommended that any new length of wire rope which will be assessed by NDT equipment be inspected as soon as it is installed. This inspection will then be the baseline for future NDT inspections from which LMA and other anomalies can be assessed.

NDT inspection should not be, and is not intended to be, the only means of inspection. NDT inspections should always be considered an aid or supplement to a careful and proper visual inspection. The output of an NDT will indicate areas of the rope that need closer inspection.

None of the NDT devices in use can measure loss of strength. Any attempt to estimate the loss of strength should be based on the actual rope breaking strength and not on the rope's minimum breaking force. It is very difficult and often misleading to estimate loss of strength based solely on LMA.

EQUIPMENT INSPECTION

Any undetected fault on a sheave, roller, or drum—be it of relatively major or minor significance—can cause a rope to wear out many times faster than the wear resulting from normal operations. As a positive means of minimizing abuses and other than normal wear, the procedures here set forth should be adhered to. Every observation and measurement should be carefully recorded and kept in some suitable and accessible file.

1) Give close examination to the method by which the rope is attached both to the drum and to the load. Make certain that the proper type of attachment is applied correctly, and that any safety devices in use are in satisfactory working order.
2) Carefully check the groove and working surface of every sheave, roller, and drum, to determine whether each (groove and surface) is as near to the correct diameter and contour as circumstances will permit, and whether all surfaces that are in contact with the rope are smooth and free of corrugations or other abrasive defects.
3) Check sheaves and rollers to determine whether each turns freely, and whether they are properly aligned with the travel of the rope. All bearings must be in good operating condition and furnish adequate support to the sheaves and rollers. Sheaves that are permitted to wobble will create additional forces that accelerate the degradation of the rope.
4) If starter, filler, and riser strips on drums are used, check their condition and location. Should these be worn, improperly located or badly designed, they will cause poor spooling, doglegs, and other rope damage.
5) Wherever possible, follow the path that the rope will follow through a complete operating cycle. Be on the lookout for spots on the equipment that have been worn bright or cut into by the rope as it moves through the system. Ordinarily, excessive abrasive wear on the rope can be eliminated at these points by means of some type of protector or roller.

FIELD LUBRICATION

Standard wire ropes are lubricated during the manufacturing process; the kind and amount of lubricant depends on the rope's size, type, and use. The lubrication applied to the rope at manufacturing will provide the finished rope with ample protection for a reasonable time if it is stored under proper conditions. But, when the rope is put into service, the initial lubrication will normally be less than needed for the full useful life of the rope. Because of this, periodic replacement applications of a suitable rope lubricant are necessary.

Following are the important characteristics of a good wire rope lubricant:

1) It should be free from acids and alkalis.
2) It should have sufficient adhesive strength to remain on the ropes.
3) It should be of a viscosity capable of penetrating the interstices between wires and strands.
4) It should not be soluble in the medium surrounding it under the actual operating conditions.
5) It should have a high film strength.
6) It should have anti-corrision additives.

Note: Used lubricants from other applications, such as used motor oil, should not be used on wire ropes as they may contain harmful alkalis, acids or solids.

Before applying lubrication, accumulations of dirt or other abrasive material should be removed from the rope. Cleaning is accomplished with rags, a stiff wire brush dipped in solvent or compressed air. Immediately after it is cleaned, the rope should be lubricated. When it is normal for the rope to operate in dirt, rock or other abrasive material, the lubricant should be selected with great care to make certain that it will penetrate and, at the same time, will not pick up abnormal amounts of the material through which the rope must be dragged.

As a general rule, the most efficient and most economical means to do field lubrication/protection is by using some method or system that continuously applies the lubricant while the rope is in operation. Many techniques are used; these include the continuous bath, dripping, pouring, swabbing, painting, or where circumstances dictate, automatic systems can be used to apply lubricants either by a drip or pressure spray method. (Fig. 62).

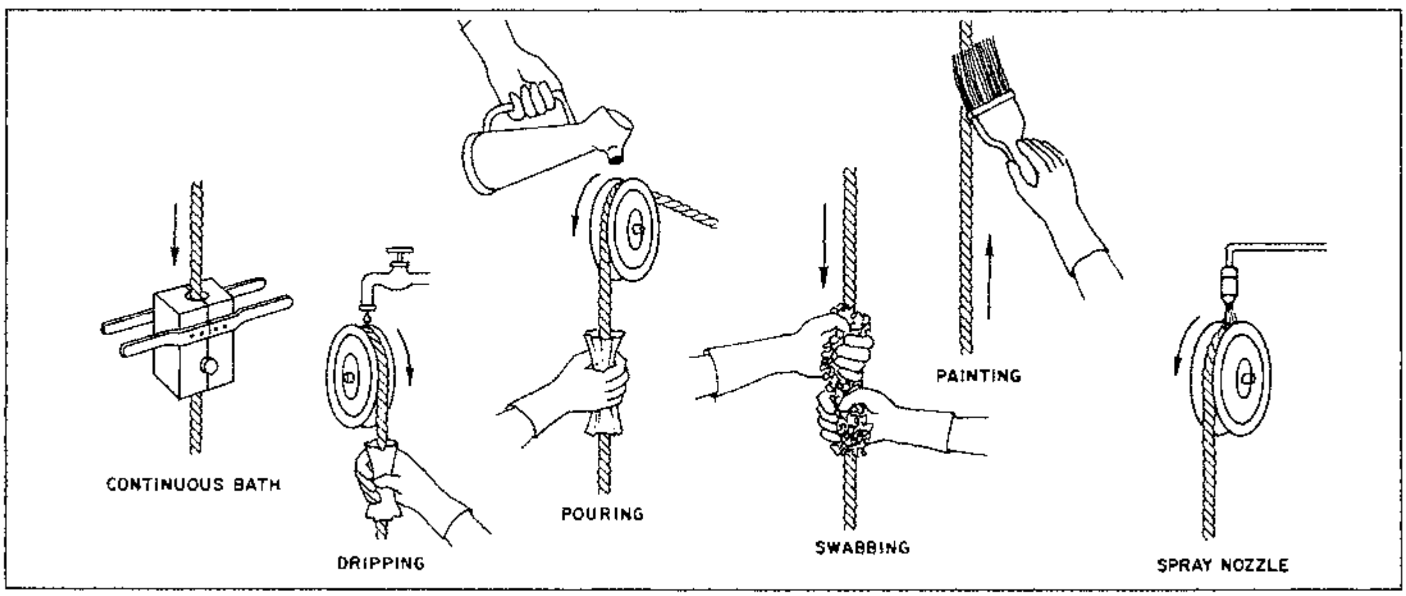


Figure 62. Typical methods of lubricant application in general use , including continuous bath, dripping, pouring, swabbing, painting, and spraying. If the lubricant is applied when the rope is bent, the lubricant will normally penetrate much easier. Arrows indicate the direction of the rope movement. Because of potential hazards to personnel during hand lubrication, extreme care should be taken during these procedures.

WIRE ROPE EFFICIENCY WHEN OPERATING OVER SHEAVES (TACKLE BLOCK SYSTEM)

Some portion of a wire rope's strength—when operating over sheaves—is expended in turning the sheaves. In multi-part tackle block system (Fig. 63) this loss of available lifting strength can be significant.

The load on the lead line (fast line) under static (no-movement) conditions can be readily calculated if the load is divided by the number of parts of line as expressed in the following formula:

$$\text{Fast line load} = \frac{\text{Total load (incl. slings, containers, etc.)}}{\text{Number of parts of line}}$$

For example, in a four-part system (Fig. 63D) lifting 6000 lb, the lead line load will equal:

$$\frac{6000 \text{ lb.}}{4 \text{ parts of line}} = \frac{6000}{4} \quad \text{or } 1500 \text{ lb.}$$

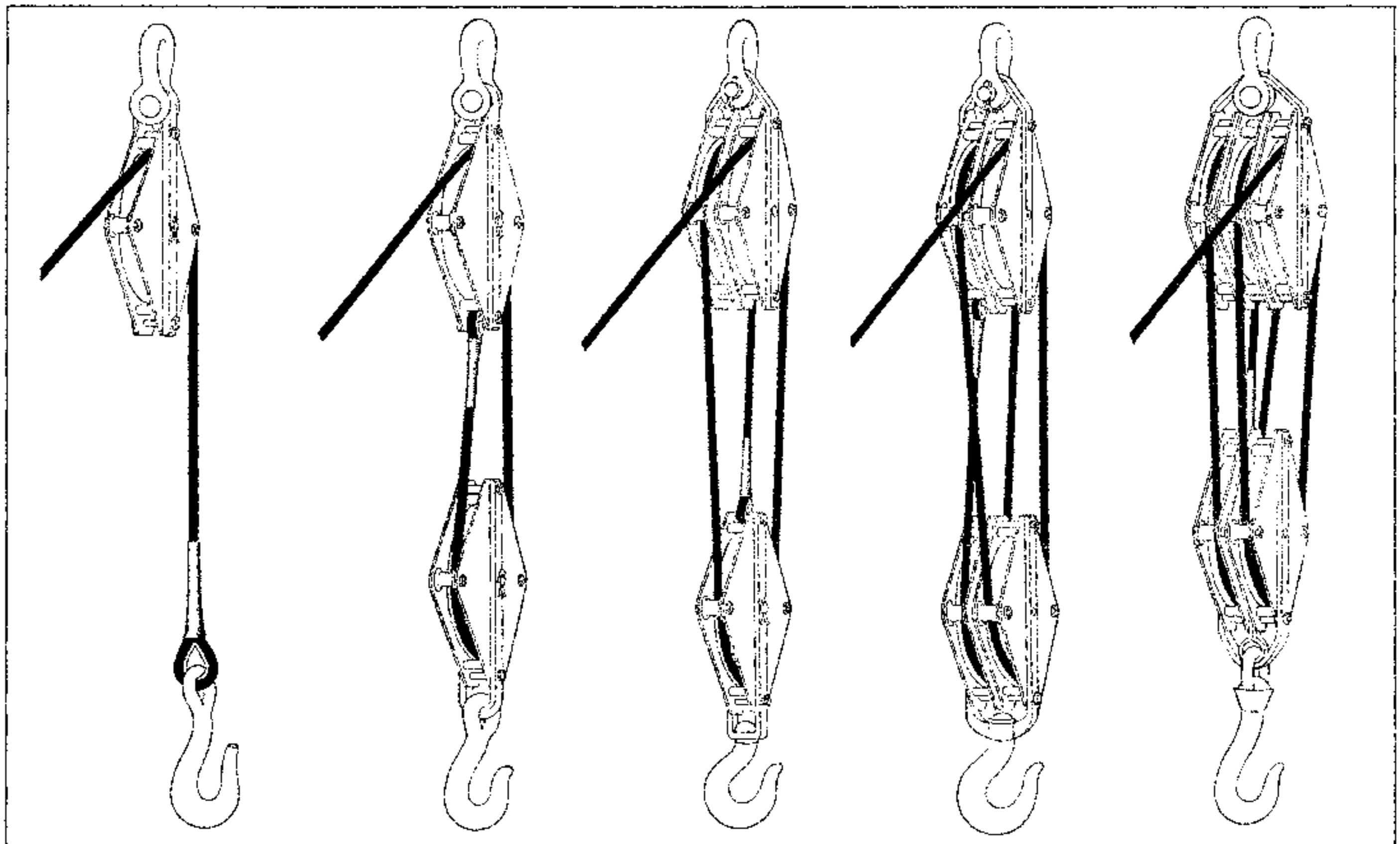


Figure 63. Commonly used single- and multiple-sheave blocks (tackles). Static loading on the rope is: A) equal to, B) 1/2 of, C) 1/3 of, D) 1/4 of, and E) 1/5 of the supported load. NOTE: Only the parts of line between the top (crown) block and the bottom (traveling) block are counted when determining the numbers of parts of line.

As noted, the available lifting strength is reduced by the friction of turning the sheaves. The Lead-Line Factors shown below give values to allow the user to calculate the loss due to this friction. The loss is determined by the type of bearings in the lifting system sheave blocks. The schematic diagram (Fig. 64) shows 4-part reeving. This system has the same number of sheaves as there are parts of line. The following procedure presumes this condition throughout. Provision for extra lead sheaves are given at the end of this discussion. To calculate the lead line load, the combined load of the container, contents and lifting attachments is multiplied by the lead line factor as follows:

Lead line load = lead line factor x load.

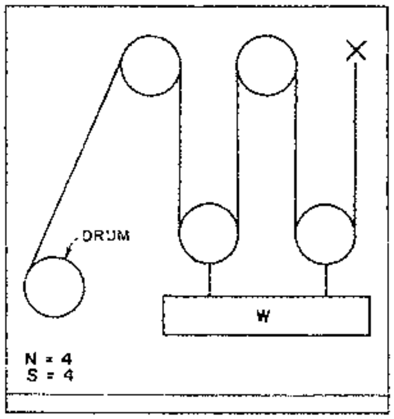


Figure 64. Schematic representation of a four-part reeving system, N=the number of parts of line supporting the load (W), and S=the number of rotating sheaves.

For example, if the four-part lifting system in the previous example has ball or roller bearings in the sheaves, the lead line load will increase from 1500 lb. to 1650 lb. when the load starts to move. On the other hand, if the sheaves have plain bearings such as bronze bushings, the lead line load will increase to 1854 lb.

Today, many cranes, derricks and other lifting systems use 8 or more parts of line in various parts of the reeving. The effect on multi-part systems can be quite significant and must be included in the calculations of any lift plan. To show the impact of these factors, in an 8-part system with plain bearings lifting a 6000 lb. load, the lead line load jumps from 750 lb. in a static condition to 1086 lb. This is an increase of 45%!

TABLE 16 LEAD LINE FACTORS*

Parts of Line	With Plain Bearing Sheaves	With Roller Bearing Sheaves
1	1.09	1.04
2	.568	.530
3	.395	.360
4	.309	.275
5	.257	.225
6	.223	.191
7	.199	.167
8	.181	.148
9	.167	.135
10	.156	.123
11	.147	.114
12	.140	.106
13	.133	.100
14	.128	.095
15	.124	.090

*In using this table, the user should note that it is based on the assumption that the number of parts of line (N) is equal to the number of sheaves (S). When S exceeds N, refer to the next page.

It should be noted that other bearing materials and types are available. When using these other types, their coefficient of friction should be used in the calculations.

Fig. 65 shows a similar 4-part system with an additional lead in sheave. In such cases, for each additional sheave the tabulated value is multiplied by 1.09 for plain bearings, or 1.04 for anti-friction bearings.

Example: What is the lead-line factor for a plain bearing lifting system of 4 parts of line and two extra lead in sheaves? The tabulated value is 0.309. Since there are two additional sheaves, the computation is:

$$.309 \times 1.09 \times 1.09 = .367$$

What is the lead line load on this system with a 6000 lb. load?

$$6000 \times .367 = 2202 \text{ lb.}$$

It should be emphasized that the "dead-end" of the rope may also be subjected to this augmented load.

Systems in which both rope ends are attached to a drum, as found in some overhead cranes are outside the scope of this discussion. Similar tables and equations are available for these systems. Rather than going into those factors in this manual, it is suggested that information on such systems be obtained directly from your wire rope supplier.

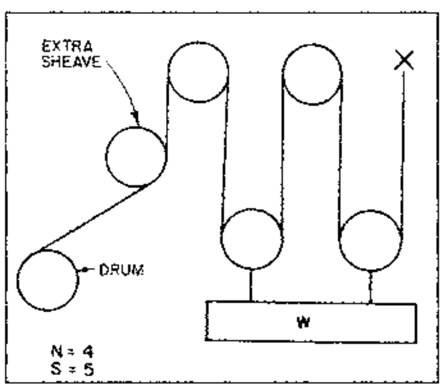


Figure 65. Schematic representation of a 4-part reeving system with an extra (idler) sheave.

6 Physical Properties

ELASTIC PROPERTIES OF WIRE ROPE

The following discussion relates to conventional 6- or 8-strand ropes that have either fiber or steel cores; it is not applicable to rotation-resistant ropes since these constitute a separate case.

Wire rope is an elastic member; it stretches or elongates under load. This stretch derives from two sources:

1) *constructional,* and
2) *elastic.*

In actuality, there may be a third source of stretch—a result of the rope rotating on its own axis. Such elongation, which may occur either as a result of using a swivel, or from the effect of a free-turning load, is brought about by the unlaying of the rope strands. Because the third source is not a recommeded occurrence, it is a subject that is beyond the scope of this publication. Our discussion will be limited to *constructional* and *elastic stretch.*

CONSTRUCTIONAL STRETCH

When a load is applied to wire rope, the helically-laid wires and strands act in a constricting manner thereby compressing the core and bringing all the rope elements into closer contact. The result is a slight reduction in the rope's diameter and an accompanying lengthening of the rope.

Constructional stretch is influenced by the following factors:

1) *type of core* (fiber or steel)
2) *rope construction* (6 x 7, 6 x 25 FW, 6 x 41 WS, 8 x 19S, etc.)
3) *length of lay,*
4) *material*

Ropes with wire strand core (WSC) or independent wire rope core (IWRC) have less constructional stretch than those with fiber core (FC). The reason for this is that steel cannot compress as much as the fiber can.

Usually, constructional stretch will cease at an early stage in the rope's life. However, some fiber core ropes, if lightly loaded (as in the case of elevator ropes), may display a degree of constructional stretch over a considerable portion of their life.

A definite value for determining constructional stretch cannot be assigned since it is influenced by several factors. The following table gives some idea of the approximate total constructional stretch as a percentage of rope length.

Rope construction	*Approximate Total Constructional Stretch*
6 strand FC	1/2% - 3/4%
6 strand IWRC	1/4% - 1/2%
8 strand FC	3/4% - 1%
8 strand IWRC	1/2% - 3/4%

ELASTIC STRETCH

Elastic stretch results from recoverable deformation of the steel itself. Here, again, a quantity cannot be precisely calculated. However, the following equation can provide a reasonable approximation for a good many situations.

$$\text{Changes in length (ft)} = \frac{\text{Change in load (lb) x Length (ft)}}{\text{Area (inches}^2\text{)x Modulus of Elasticity (psi)}}$$

The modulus of elasticity is given in Table 17, and the area can be found in Table 18.

TABLE 17 APPROXIMATE MODULUS OF ELASTICITY PSI*

Rope Classification	Zero through 20% Loading	21% to 65% Loading
6 x 7 with fiber core	11,700,000	13,000,000
6 x 19 with fiber core	10,800,000	12,000,000
6 x 36 with fiber core	9,900,000	11,000,000
8 x 19 with fiber core	8,100,000	9,000,000
6 x 19 with IWRC	13,500,000	15,000,000
6 x 36 with IWRC	12,600,000	14,000,000
8 x 19 with IWRC	12,000,000	13,500,000
8 x 36 with IWRC	11,500,000	13,000,000

*Applicable to new rope with constructional stretch removed.

EXAMPLE: How much *elastic stretch* is expected to occur in 200 ft of 1/2 inch 6 x 25 FW EIP IWRC rope when loaded to 20% of its minimum breaking force?

Minimum Breaking Force = 13.3tons (26,600 lb)
20% of which = 5,320 lb.

Area of 1/2 inch is found by squaring the diameter and multiplying it by the area of 1 inch rope given in Table 18 under the "IWRC" heading and opposite 6 x 25 FW. i.e., 1/2 x 1/2 x .483=.121.

The modulus of elasticity is found in Table 17 opposite the 6 x 19 IWRC (because 6 x 25FW is a member of this classification) and under the "Zero through 20% Loading." i.e. 13,500,000 psi.

Substituting these values, the equation reads as follows:
Change in length =(5320 x 200) / (.121 x 13,500,000) = 0.65 feet or 7.8 inches.

$$\text{Change in length} = \frac{5320 \times 200}{.121 \times 13{,}500{,}000}$$

$$= .65 \text{ Ft (7.8 inches)}$$

A word of caution concerning the use of Table 17: the higher modulus given under the "21% to 65% Loading" is based on the assumption that both the initial and the final load fall within this range. If the above example were restated to the effect that the load was 35% (or 9,310 lb) of the minimum breaking force, it would be incorrect to rework the problem simply by making two substitutions: the new load and the higher modulus of 15,000,000 psi. To do so would ignore the greater stretch that occurs at the lower modulus during the initial loading.

TABLE 18
APPROXIMATE METALLIC AREAS OF ONE-INCH ROPE
OF VARIOUS CONSTRUCTIONS*

Construction	Fiber Core	IWRC or WSC	Cable Laid
5 x 7	.390	.457	
6 x 6	.320	.386	
6 x 7	.384	.451	
6 x 12	.232		
6 x 19 12/7	.376	.442	
6 x 19 S	.404	.470	
6 x 19 W	.416	.482	
6 x 21 FW	.412	.478	
6 x 21 S	.411	.477	
6 x 24 15/9	.329		
6 x 25 FW	.417	.483	
6 x 26 WS	.409	.476	
6 x 29 FW	.420	.486	
6 x 31 12/19	.385	.452	
6 x 31 WS	.414	.481	
6 x 33 FW	.423	.490	
6 x 36 WS	.419	.485	
6 x 37 18/19 W	.393	.459	
6 x 37 FW	.427	.493	
6 x 41 SFW	.425	.491	
6 x 41 WS	.424	.490	
6 x 42 Tiller	.231		
6 x 43 FWS	.392	.458	
6 x 46 SFW	.425	.492	
6 x 46 WS	.426	.492	
6 x 61 FWS	.408	.474	
7 x 7		.471	
7 x 19 12/7		.466	
7 x 19 W		.505	
8 x 7	.343	.474	
8 x 19 S	.359	.472	
8 x 19 W	.366	.497	
8 x 25 FW	.368	.499	
8 x 19 FW	.366	.499	
18 x 7	.422		
19 x 7		.453	
6 x 3 x 19			.122
7 x 7 x 7			.343
7 x 7 x 19			.361

* Values given are based on 3% oversize because this is a common design "target." But, this figure often varies and is not to be considered a standard. Wire sizes in specific constructions also vary, thus the given values are approximate. They are, however, within the range of accuracy of the entire method that is, in itself, approximate. For constructions, consult the rope manufacturer.

As indicated, it is necessary to know the rope area in order to solve the previously given stretch equation.

For diameters other than 1 inch, multiply the area given in this table by the square of the nominal rope diameter.

Example: To find the area of 1/2" 6 x 36 WS IWRC

From the table: .485

Diameter squared: $(1/2)^2=1/4$ or $.5 \times .5 = .25$

Multiply table value by diameter squared:

Area $= .25 \times .485 = .121$ inches^2

Example: To find the area of 1-1/4" 6 x 25 FW FC

Answer: $(1.25)^2 \times .417 = 1.563 \times .417 = .652$ inches^2

In this instance, the problem would be worked out in two parts: the first follows the above equation, and in the second part, the load starts at 5,230 lb and ends at 79,310 lb, and 15,000,000 psi is used as the modulus. Thus:

$$\text{Change in length} = \frac{(9{,}310 - 5{,}320) \times 200.65}{.121 \times 15{,}000{,}000} = .44 \text{ ft (5.3 inches)}$$

Note that because the length of the rope used was in feet, the answer (change in length) is also in feet.

To this figure, the previously determined 7.8 inches must be added.

Hence, elastic stretch of this rope at 35% of its minimum breaking force would be approximately:

Elastic stretch:

@ 0 through 20% =	.65 ft (7.8 inches)
@ 21%-35% =	.44 ft (5.3 inches)
TOTAL STRETCH =	1.09 ft (13.1 inches)

Where it is necessary to have precise data on elastic characteristics, a load vs. elongation test must be performed on a representative sample of the rope under consideration.

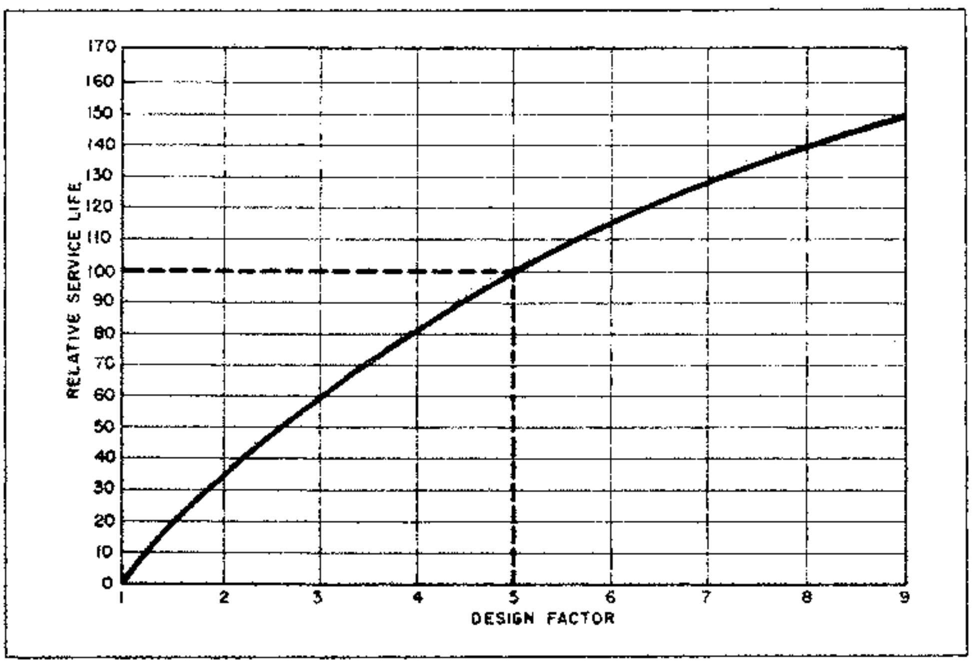


Figure 66. This graph is called the *Relative Service Life Curve*. It relates the service life to operating loads. A design factor of 5 is chosen most frequently.

For certain applications, ropes may be prestretched in order to remove some of the constructional stretch. Frequently, this treatment is used on structural members such as bridge rope and strand. In some cases, prestretching is applied to operating ropes where elongation in service from constructional stretch may present problems, e.g., elevator and skip hoist ropes.

While a prestretching technique has value, some of the benefit is lost in reeling and handling.

DESIGN FACTORS

The *design factor* is defined as the ratio of the minimum breaking force of a wire rope to the total load it is expected to carry. Hence, the design factor that is selected plays an important part in determining the rope's service life. Excessive loading, whether continuous or sporadic, will greatly impair a rope's serviceability. Usually, the choice of a certain wire rope size and grade will be based on static loading and, under static conditions, it is sufficient for its task.

Figure 66, the *Wire Rope Relative Service Life Curve*, shows how the service life can be reduced as operating loads are increased or can be increased if the operating loads are decreased. It should be noted that the relative change is comparative of one design factor to another. For example, a change in the *design factor* from 5 to 3 decreases its life expectancy index from 100 to 60–a drop of 40%.

MINIMUM BREAKING FORCE TABLES

The *minimum breaking force (called nominal strength in some specifications)* given in tables 19 through 43, has been calculated by a consensus, industry-accepted procedure, and manufacturers design wire rope to these strengths. When making design calculations, it should be noted that the given figures are the *static strengths*. Designers should base their calculations on these strengths.

The *actual breaking force* is the ultimate load registered on a wire rope sample during a tension test. Unless otherwise required, once the load on a rope during a tensile test reaches the minimum breaking force value, the test is successful. Variables in rope testing can only cause a reduction in the rope breaking strength, never an increase.

Various standards and specifications have tensile test method requirements. These may include length of sample tested, sample preparation requirements, speed of tensile machine and validity of test results if failure is near end termination.

TABLE 19 MINIMUM BREAKING FORCE OF WIRE ROPE
6 x 7 Classification/Bright (Uncoated), Fiber Core

Nominal Diameter		Approximate Mass		Minimum Breaking Force* Improved Plow Steel**	
inches	mm	lb/ft	kg/m	tons	metric tonnes
1/4	6.4	0.09	0.14	2.64	2.40
5/16	7.9	0.15	0.22	4.10	3.72
3/8	9.5	0.21	0.31	5.86	5.32
7/16	11.1	0.29	0.43	7.93	7.20
1/2	12.7	0.38	0.57	10.3	9.35
9/16	14.3	0.48	0.71	13.0	11.8
5/8	15.9	0.59	0.88	15.9	14.4
3/4	19.1	0.84	1.25	22.7	20.6
7/8	22.2	1.15	1.71	30.7	27.9
1	25.4	1.50	2.23	39.7	36.0
1-1/8	28.6	1.90	2.83	49.8	45.2
1-1/4	31.8	2.34	3.48	61.0	55.3
1-3/8	34.9	2.82	4.23	73.1	66.3
1-1/2	38.1	3.38	5.03	86.2	78.2

* To convert to Kilonewtons (kN), multiply tons (minimum breaking force) by 8.896;
1 lb = 4.448 newtons (N).

** Minimum breaking forces listed above apply to ropes with bright or drawn galvanized wires.
Minimum breaking forces are 10% lower for ropes with wires galvanized at finish size.

TABLE 20 MINIMUM BREAKING FORCE OF WIRE ROPE
6 x 7 Classification/Bright (Uncoated), IWRC

Nominal Diameter		Approximate Mass		Minimum Breaking Force*	
				Improved Plow Steel**	
inches	mm	lb/ft	kg/m	tons	metric tonnes
1/4	6.4	0.10	0.15	2.84	2.58
5/16	7.9	0.16	0.24	4.41	4.00
3/8	9.5	0.23	0.34	6.30	5.72
7/16	11.1	0.32	0.48	8.52	7.73
1/2	12.7	0.42	0.63	11.1	10.1
9/16	14.3	0.53	0.79	14.0	12.7
5/8	15.9	0.65	0.97	17.1	15.5
3/4	19.1	0.92	1.37	24.4	22.1
7/8	22.2	1.27	1.89	33.0	29.9
1	25.4	1.65	2.46	42.7	38.7
1-1/8	28.6	2.09	3.11	53.5	48.5
1-1/4	31.8	2.57	3.82	65.6	59.5
1-3/8	34.9	3.12	4.64	78.6	71.3
1-1/2	38.1	3.72	5.54	92.7	84.1

* To convert to Kilonewtons (kN), multiply tons (minimum breaking force) by 8.896; 1 lb = 4.448 newtons (N).

** Minimum breaking forces listed above apply to ropes with bright or drawn galvanized wires. Minimum breaking forces are 10% lower for ropes with wires galvanized at finish size.

TABLE 21 MINIMUM BREAKING FORCE OF WIRE ROPE
6 x 19 Classification/Bright (Uncoated), Fiber Core

Nominal Diameter		Approximate Mass		Minimum Breaking Force*			
				Improved Plow Steel**		Extra Improved Plow**	
inches	mm	lb/ft	kg/m	tons	metric tonnes	tons	metric tonnes
1/4	6.4	0.11	0.16	2.74	2.49	3.02	2.74
5/16	7.9	0.16	0.24	4.26	3.86	4.69	4.25
3/8	9.5	0.24	0.35	6.10	5.53	6.72	6.10
7/16	11.1	0.32	0.48	8.27	7.50	9.10	8.26
1/2	12.7	0.42	0.63	10.7	9.71	11.8	10.7
9/16	14.3	0.53	0.79	13.5	12.2	14.9	13.5
5/8	15.9	0.66	0.98	16.7	15.1	18.3	16.6
3/4	19.1	0.95	1.41	23.8	21.6	26.2	23.8
7/8	22.2	1.29	1.92	32.2	29.2	35.4	32.1
1	25.4	1.68	2.50	41.8	37.9	46.0	41.7
1-1/8	28.6	2.13	3.17	52.6	47.7	57.8	52.4
1-1/4	31.8	2.63	3.91	64.6	58.6	71.1	64.5
1-3/8	34.9	3.18	4.73	77.7	70.5	85.5	77.6
1-1/2	38.1	3.78	5.63	92.0	83.5	101	91.6
1-5/8	41.3	4.44	6.61	107	97.1	118	107
1-3/4	44.5	5.15	7.66	124	112	137	124
1-7/8	47.6	5.91	8.80	141	128	156	142
2	50.8	6.72	10.0	160	145	176	160
2-1/8	54	7.59	11.3	179	162	197	179
2-1/4	57.2	8.51	12.7	200	181	220	200

* To convert to Kilonewtons (kN), multiply tons (minimum breaking force) by 8.896;
1 lb = 4.448 newtons (N).

** Minimum breaking forces listed above apply to ropes with bright or drawn galvanized wires. Minimum breaking forces are 10% lower for ropes with wires galvanized at finish size.

TABLE 22 MINIMUM BREAKING FORCE OF WIRE ROPE
6 x 19 Classification/Bright (Uncoated), IWRC

Nominal Diameter		Approximate Mass		Minimum Breaking Force*					
				Improved Plow Steel**		Extra Improved Plow Steel**		Extra Extra Improved Plow**	
inches	mm	lb/ft	kg/m	tons	metric tonnes	tons	metric tonnes	tons	metric tonnes
1/4	6.4	0.12	0.17	2.94	2.67	3.40	3.08	3.74	3.39
5/16	7.9	0.18	0.27	4.58	4.16	5.27	4.78	5.80	5.26
3/8	9.5	0.26	0.39	6.56	5.95	7.55	6.85	8.30	7.53
7/16	11.1	0.35	0.52	8.89	8.07	10.2	9.25	11.2	10.2
1/2	12.7	0.46	0.68	11.5	10.4	13.3	12.1	14.6	13.2
9/16	14.3	0.59	0.88	14.5	13.2	16.8	15.2	18.5	16.8
5/8	15.9	0.72	1.07	17.7	16.2	20.6	18.7	22.7	20.6
3/4	19.1	1.04	1.55	25.6	23.2	29.4	26.7	32.4	29.4
7/8	22.2	1.42	2.11	34.6	31.4	39.8	36.1	43.8	39.7
1	25.4	1.85	2.75	44.9	40.7	51.7	46.9	56.9	51.6
1-1/8	28.6	2.34	3.48	56.5	51.3	65.0	59.0	71.5	64.9
1-1/4	31.8	2.89	4.30	69.4	63.0	79.9	72.5	87.9	79.7
1-3/8	34.9	3.50	5.21	83.5	75.7	96.0	87.1	106	96.2
1-1/2	38.1	4.16	6.19	98.9	89.7	114	103	125	113
1-5/8	41.3	4.88	7.26	115	104	132	120	146	132
1-3/4	44.5	5.67	8.44	133	121	153	139	169	153
1-7/8	47.6	6.50	9.67	152	138	174	158	192	174
2	50.8	7.39	11.0	172	156	198	180	217	197
2-1/8	54.0	8.35	12.4	192	174	221	200	244	221
2-1/4	57.2	9.36	13.9	215	195	247	224	272	247
2-3/8	60.3	10.4	15.5	239	217	274	249	302	274
2-1/2	63.5	11.6	17.3	262	238	302	274	332	301
2-5/8	66.7	12.8	19.0	288	261	331	300	364	330
2-3/4	79.9	14.0	20.8	314	285	361	327	397	360

* To convert to Kilonewtons (kN), multiply tons (minimum breaking force) by 8.896; 1 lb = 4.448 newtons (N).

** Minimum breaking forces listed above apply to ropes with bright or drawn galvanized wires. Minimum breaking forces are 10% lower for ropes with wires galvanized at finish size.

TABLE 23 MINIMUM BREAKING FORCE OF WIRE ROPE
6 x 36 Classification/Bright (Uncoated), Fiber Core

Nominal Diameter		Approximate Mass		Minimum Breaking Force*			
				Improved Plow Steel**		Extra Improved Plow Steel**	
inches	mm	lb/ft	kg/m	tons	metric tonnes	tons	metric tonnes
1/4	6.4	0.11	0.16	2.74	2.49	3.02	2.74
5/16	7.9	0.16	0.24	4.26	3.86	4.69	4.25
3/8	9.5	0.24	0.35	6.10	5.53	6.72	6.10
7/16	11.1	0.32	0.48	8.27	7.50	9.10	8.26
1/2	12.7	0.42	0.63	10.7	9.71	11.8	10.7
9/16	14.3	0.53	0.79	13.5	12.2	14.9	13.5
5/8	15.9	0.66	0.98	16.7	15.1	18.3	16.6
3/4	19.1	0.95	1.41	23.8	21.6	26.2	23.8
7/8	22.2	1.29	1.92	32.2	29.2	35.4	32.1
1	25.4	1.68	2.50	41.8	37.9	46.0	41.7
1-1/8	28.6	2.13	3.17	52.6	47.7	57.8	52.4
1-1/4	31.8	2.63	3.91	64.6	58.6	71.1	64.5
1-3/8	34.9	3.18	4.73	77.7	70.5	85.5	77.6
1-1/2	38.1	3.78	5.63	92.0	83.5	101	91.6
1-5/8	41.3	4.44	6.61	107	97.1	118	107
1-3/4	44.5	5.15	7.66	124	112	137	124
1-7/8	47.6	5.91	8.80	141	128	156	142
2	50.8	6.72	10.0	160	145	176	160
2-1/8	54.0	7.59	11.3	179	162	197	179
2-1/4	57.2	8.51	12.7	200	181	220	200

* To convert to Kilonewtons (kN), multiply tons (minimum breaking force) by 8.896;
1 lb = 4.448 newtons (N).

** Minimum breaking forces listed above apply to ropes with bright or drawn galvanized wires. Minimum breaking forces are 10% lower for ropes with wires galvanized at finish size.

TABLE 24 MINIMUM BREAKING FORCE OF WIRE ROPE

6x36 Classification/Bright (Uncoated), IWRC

Nominal Diameter		Approximate Mass		Minimum Breaking Force*					
				Improved Plow Steel**		Extra Improved Plow Steel**		Extra Extra Improved Plow Steel**	
inches	mm	lb/ft	kg/m	ton	metric tonnes	tons	metric tonnes	tons	metric tonnes
1/4	6.4	0.12	0.17	2.94	2.67	3.40	3.08	3.74	3.39
5/16	7.9	0.18	0.27	4.58	4.16	5.27	4.78	5.80	5.26
3/8	9.5	0.26	0.39	6.56	5.95	7.55	6.85	8.30	7.53
7/16	11.1	0.35	0.52	8.89	8.07	10.2	9.25	11.2	10.2
1/2	12.7	0.46	0.68	11.5	10.4	13.3	12.1	14.6	13.2
9/16	14.3	0.59	0.88	14.5	13.2	16.8	15.2	18.5	16.8
5/8	15.9	0.72	1.07	17.9	16.2	20.6	18.7	22.7	20.6
3/4	19.1	1.04	1.55	25.6	23.2	29.4	26.7	32.4	29.4
7/8	22.2	1.42	2.11	34.6	31.4	39.8	36.1	43.8	39.7
1	25.4	1.85	2.75	44.9	40.7	51.7	46.9	56.9	51.6
1-1/8	28.6	2.34	3.48	56.5	51.3	65.0	59.0	71.5	64.9
1-1/4	31.8	2.89	4.30	69.4	63.0	79.9	72.5	87.9	80.0
1-3/8	34.9	3.50	5.21	83.5	75.7	96.0	87.1	106	96.2
1-1/2	38.1	4.16	6.19	98.9	89.7	114	103	125	113
1-5/8	41.3	4.88	7.26	115	104	132	120	146	132
1-3/4	44.5	5.67	8.44	133	121	153	139	169	153
1-7/8	47.6	6.50	9.67	152	138	174	158	192	174
2	50.8	7.39	11.0	172	156	198	180	217	197
2-1/8	54.0	8.35	12.4	192	174	221	200	244	221
2-1/4	57.2	9.36	13.9	215	195	247	224	282	256
2-3/8	60.3	10.4	15.5	239	217	274	249	302	274
2-1/2	63.5	11.6	17.3	262	238	302	274	332	301
2-5/8	66.7	12.8	19.0	288	261	331	300	364	330
2-3/4	79.9	14.0	20.8	314	285	361	327	397	360
2-7/8	73.0	15.3	22.8	341	309	392	356	432	392
3	76.2	16.6	24.7	370	336	425	386	468	425
3-1/8	79.4	18.0	26.8	399	362	458	415	504	457
3-1/4	82.6	19.5	29.0	429	389	492	446	543	493
3-3/8	85.7	21.0	31.3	459	416	529	480	582	528
3-1/2	88.9	22.7	33.8	491	445	564	512	621	563
3-5/8	92.1	24.3	36.2	523	458	602	528	663	601
3-3/4	95.3	26.0	38.7	558	505	641	581	705	640

* To convert to Kilonewtons (kN), multiply tons (minimum breaking force) by 8.896;
1 lb = 4.448 newtons (N).

** Minimum breaking forces listed above apply to ropes with bright or drawn galvanized wires. Minimum breaking forces are 10% lower for ropes with wires galvanized at finish size.

TABLE 25 MINIMUM BREAKING FORCE OF WIRE ROPE
6 x 61 Classification/Bright (Uncoated), IWRC

Nominal Diameter		Approximate Mass		Minimum Breaking Force*			
				Improved Plow Steel**		Extra Improved Plow Steel**	
inches	mm	lb/ft	kg/m	tons	metric tonnes	tons	metric tonnes
3	76.2	16.6	24.7	360	327	414	376
3-1/4	82.6	19.5	29.0	419	380	483	438
3-3/8	85.7	21.0	31.3	451	409	518	470
3-1/2	88.9	22.7	33.8	483	438	555	503
3-3/4	95.3	26.0	38.7	549	498	632	573
4	101.6	29.6	44.1	620	562	713	647
4-1/4	108.0	33.3	49.6	694	630	799	725
4-1/2	114.3	37.4	55.7	772	700	888	806
4-3/4	120.7	41.7	62.1	853	774	981	890
5	127.0	46.2	68.8	937	850	1078	978

* To convert to Kilonewtons (kN), multiply tons (minimum breaking force) by 8.896;
1 lb = 4.448 newtons (N).

** Minimum breaking forces listed above apply to ropes with bright or drawn galvanized wires. Minimum breakir forces are 10% lower for ropes with wires galvanized at finish size.

TABLE 26 MINIMUM BREAKING FORCE OF WIRE ROPE
6 x 91 Classification/Bright (Uncoated), IWRC

Nominal Diameter		Approximate Mass		Minimum Breaking Force*			
				Improved Plow Steel**		Extra Improved Plow Steel**	
inches	mm	lb/ft	kg/m	tons	metric tonnes	tons	metric tonnes
4	101.6	29.6	44.1	589	534	677	614
4-1/4	108.0	33.3	49.6	660	599	759	689
4-1/2	114.3	37.4	55.7	734	666	844	766
4-3/4	120.7	41.7	62.1	810	735	932	846
5	127.0	46.2	68.7	891	808	1024	929
5-1/4	133.4	49.8	74.1	974	884	1120	1016
5-1/2	139.7	54.5	81.1	1060	962	1219	1106
5-3/4	146.1	59.6	88.7	1148	1041	1320	1198
6	152.4	65.0	96.7	1240	1125	1426	1294

* To convert to Kilonewtons (kN), multiply tons (minimum breaking force) by 8.896;
1 lb = 4.448 newtons (N).

** Minimum breaking forces listed above apply to ropes with bright or drawn galvanized wires. Minimum breaking forces are 10% lower for ropes with wires galvanized at finish size.

TABLE 27 MINIMUM BREAKING FORCE OF WIRE ROPE
6 x 25 B, 6 x 27 H & 6 x 30 G Flattened Strand/Bright (Uncoated), Fiber Core

Nominal Diameter		Approximate Mass		Minimum Breaking Force*					
				Improved Plow Steel**		Extra Improved Plow Steel**		Extra Extra Improved Plow Steel**	
inches	mm	lb/ft	kg/m	tons	metric tonnes	tons	metric tonnes	tons	metric tonnes
1/2	12.7	0.45	0.67	11.8	10.8	13.0	11.8	14.3	13.0
9/16	14.3	0.57	0.85	14.9	13.5	16.4	14.9	18.0	16.3
5/8	15.9	0.70	1.04	18.3	16.6	20.1	18.2	22.1	20.0
3/4	19.1	1.01	1.50	26.2	23.8	28.8	26.1	31.7	28.8
7/8	22.2	1.39	2.07	35.4	32.1	38.9	35.3	42.8	38.8
1	25.4	1.80	2.68	46.0	41.7	50.6	45.9	55.7	50.5
1-1/8	28.6	2.28	3.39	57.9	52.5	63.7	57.8	70.1	63.6
1-1/4	31.8	2.81	4.18	71.0	64.4	78.1	70.9	85.9	77.9
1-3/8	34.9	3.40	5.06	85.5	77.6	94.1	85.4	103	93.4
1-1/2	38.1	4.05	6.03	101	91.6	111	101	122	111
1-5/8	41.3	4.75	7.07	118	107	130	118	143	130
1-3/4	44.5	5.51	8.20	138	123	152	138	167	151
1-7/8	47.6	6.33	9.42	155	141	171	155	188	171
2	50.8	7.20	10.7	176	160	194	176	213	193

* To convert to Kilonewtons (kN), multiply tons (minimum breaking force) by 8.896;
1 lb = 4.448 newtons (N).

** Minimum breaking forces listed above apply to ropes with bright or drawn galvanized wires. Minimum breaking forces are 10% lower for ropes with wires galvanized at finish size.

TABLE 28 MINIMUM BREAKING FORCE OF WIRE ROPE
6 x 25 B, 6 x 27 H & 6 x 30 G Flattened Strand/Bright (Uncoated), IWRC

Nominal Diameter		Approximate Mass		Minimum Breaking Force*			
				Improved Plow Steel**		Extra Improved Plow Steel**	
inches	mm	lb/ft	kg/m	tons	metric tonnes	tons	metric tonnes
1/2	12.7	0.47	0.70	12.6	11.4	14	12.7
9/16	14.3	0.60	0.89	16.0	14.5	17.6	16.0
5/8	15.9	0.73	1.09	19.6	17.8	21.7	19.7
3/4	19.1	1.06	1.58	28.1	25.5	31	28.1
7/8	22.2	1.46	2.17	38.0	34.5	41.9	38.0
1	25.4	1.89	2.83	49.4	44.8	54.4	49.4
1-1/8	28.6	2.39	3.56	62.2	56.4	68.5	62.1
1-1/4	31.8	2.95	4.39	76.3	69.2	84.0	76.2
1-3/8	34.9	3.57	5.31	91.9	83.4	101	91.6
1-1/2	38.1	4.25	6.32	108	98	119	108
1-5/8	41.3	4.98	7.41	127	115	140	127
1-3/4	44.5	5.78	8.60	146	132	161	146
1-7/8	47.6	6.65	9.90	167	152	184	167
2	50.8	7.56	11.3	189	171	207	188

* To convert to Kilonewtons (kN), multiply tons (minimum breaking force) by 8.896;
1 lb = 4.448 newtons (N).

** Minimum breaking forces listed above apply to ropes with bright or drawn galvanized wires. Minimum breaking forces are 10% lower for ropes with wires galvanized at finish size.

TABLE 29 MINIMUM BREAKING FORCE OF WIRE ROPE
8 x 19 Classification/Bright (Uncoated), Fiber Core

Nominal Diameter		Approximate Mass		Minimum Breaking Force*	
				Improved Plow Steel**	
inches	mm	lb/ft	kg/m	tons	metric tonnes
1/4	6.4	0.10	0.15	2.35	2.13
5/16	7.9	0.15	0.22	3.65	3.31
3/8	9.5	0.22	0.33	5.24	4.75
7/16	11.1	0.30	0.45	7.09	6.43
1/2	12.7	0.39	0.58	9.23	8.37
9/16	14.3	0.50	0.74	11.6	10.5
5/8	15.9	0.61	0.91	14.3	13.0
3/4	19.1	0.88	1.31	20.5	18.6
7/8	22.2	1.20	1.79	27.7	25.1
1	25.4	1.57	2.34	36.0	32.7
1-1/8	28.6	1.99	2.96	45.3	41.1
1-1/4	31.8	2.45	3.65	55.7	50.5
1-3/8	34.9	2.97	4.42	67.1	60.7
1-1/2	38.1	3.53	5.25	79.4	72.0

* To convert to Kilonewtons (kN), multiply tons (minimum breaking force) by 8.896: 1 lb = 4.448 newtons (N).

** Minimum breaking forces listed above apply to ropes with bright or drawn galvanized wires. Minimum breaking forces are 10% lower for ropes with wires galvanized at finish size.

TABLE 30 MINIMUM BREAKING FORCE OF WIRE ROPE
8 x 19 Classification/Rotation Resistant/Bright (Uncoated), IWRC

Nominal Diameter		Approximate Mass		Minimum Breaking Force*			
				Improved Plow Steel**		Extra Improved Plow Steel**	
inches	mm	lb/ft	kg/m	tons	metric tonnes	tons	metric tonnes
1/2	12.7	0.47	0.70	10.1	9.16	11.6	10.5
9/16	14.3	0.60	0.89	12.8	11.6	14.7	13.3
5/8	15.9	0.73	1.09	15.7	14.2	18.1	16.4
3/4	19.1	1.06	1.58	22.5	20.4	25.9	23.5
7/8	22.2	1.44	2.14	30.5	27.7	35.0	31.8
1	25.4	1.88	2.80	39.6	35.9	45.5	41.3
1-1/8	28.6	2.39	3.56	49.8	45.2	57.3	51.7
1-1/4	31.8	2.94	4.37	61.3	55.6	70.5	64.0
1-3/8	34.9	3.56	5.30	73.8	67.0	84.9	77.0
1-1/2	38.1	4.24	6.31	87.3	79.2	100.	90.7

The minimum breaking forces for 8 x 19 rotation resistant ropes are applicable only when a test is conducted on a new rope that is fixed at both ends. When the rope is in use, and one end is free to rotate, the breaking force is reduced.

* To convert to Kilonewtons (kN), multiply tons (minimum breaking force) by 8.896; 1 lb = 4.448 newtons (N).

** Minimum breaking forces listed above apply to ropes with bright or drawn galvanized wires. Minimum breaking forces are 10% lower for ropes with wires galvanized at finish size.

TABLE 31 MINIMUM BREAKING FORCE OF WIRE ROPE
18 x 7 Construction/Rotation Resistant/Bright (Uncoated)

Nominal Diameter		Approximate Mass		Minimum Breaking Force*			
				Improved Plow Steel**		Extra Improved Plow Steel**	
inches	mm	lb/ft	kg/m	tons	metric tonnes	tons	metric tonnes
1/2	12.7	0.43	0.64	9.85	8.94	10.8	9.8
9/16	14.3	0.55	0.82	12.4	11.2	13.6	12.3
5/8	15.9	0.68	1.01	15.3	13.9	16.8	15.2
3/4	19.1	0.97	1.44	21.8	19.8	24.0	21.8
7/8	22.2	1.32	1.96	29.5	26.8	32.5	29.5
1	25.4	1.73	2.57	38.3	34.7	42.2	38.3
1-1/8	28.6	2.19	3.26	48.2	43.7	53.1	48.2
1-1/4	31.8	2.70	4.02	59.2	53.7	65.1	59.1
1-3/8	34.9	3.27	4.87	71.3	64.7	78.4	71.1
1-1/2	38.1	3.89	5.79	84.4	76.6	92.8	84.2

* To convert to Kilonewtons (kN), multiply tons (nominal Strength) by 8.896; 1 lb = 4.448 newtons (N).
** Available with galvanized wires at strengths 10% lower than listed, or at equivalent strengths on special request.

The minimum breaking forces are applicable only when a test is conducted on a new rope that is fixed at both ends. When the rope is in use, the breaking force is reduced when one end is free to rotate.

TABLE 32 MINIMUM BREAKING FORCE OF WIRE ROPE
19 x 7 Construction/Rotation Resistant/Bright (Uncoated)

Nominal Diameter		Approximate Mass		Minimum Breaking Force*			
				Improved Plow Steel**		Extra Improved Plow Steel**	
inches	mm	lb/ft	kg/m	tons	metric tonnes	tons	metric tonnes
1/2	12.7	0.45	0.67	9.85	8.94	10.8	9.8
9/16	14.3	0.58	0.86	12.4	11.2	13.6	12.3
5/8	15.9	0.71	1.06	15.3	13.9	16.8	15.2
3/4	19.1	1.02	1.52	21.8	19.8	24.0	21.8
7/8	22.2	1.39	2.07	29.5	26.8	32.5	29.5
1	25.4	1.82	2.71	38.3	34.7	42.2	38.3
1-1/8	28.6	2.30	3.42	48.2	43.7	53.1	48.2
1-1/4	31.8	2.84	4.23	59.2	53.7	65.1	59.1
1-3/8	34.9	3.43	5.10	71.3	64.7	78.4	71.1
1-1/2	38.1	4.08	6.07	84.4	76.6	92.8	84.2

The given strengths are applicable only when a test is conducted on a new rope fixed at both ends. When the rope is in use, the breaking strength is reduced when one end is free to rotate.

* To convert to Kilonewtons (kN), multiply tons (minimum breaking force) by 8.896;
1 lb = 4.448 newtons (N).

** Minimum breaking forces listed above apply to ropes with bright or drawn galvanized wires. Minimum breaking forces are 10% lower for ropes with wires galvanized at finish size.

TABLE 33 MINIMUM BREAKING FORCE OF WIRE ROPE
1 x 7 and 1 x 19 Small Diameter Specialty Strand, Galvanized and Corrosion Resistant

Nominal Diameter		Approximate Mass				Minimum Breaking Force**							
						Galvanized				Corrosion Resistant			
		1 x 7		1 x 19		1 x 7		1 x 19		1 x 7		1 x 19	
inches	mm	lbs./ 100ft	kg/ 30.5m*	lbs./ 100ft	kg./ 30.5m*	lb	kg	lb	kg	lb	kg	lb	kg
1/32	.8	.25	.11			185	83.9			185	83.9		
3/64	1.2	.55	.25	.55	.25	375	170	375	170	375	170	375	170
1/16	1.6	.85	.39	.85	.39	500	227	500	227	500	227	500	227
5/64	2.0			1.4	.64			800	363			800	363
3/32	2.4			2.0	.91			1200	544			1200	544
7/64	2.8			2.7	1.2			1600	726			1600	726
1/8	3.2			3.5	1.6			2100	953			2100	953
5/32	4.0			5.5	2.5			3300	1497			3300	1497
3/16	4.8			7.7	3.5			4700	2132			4700	2132
7/32	5.6			10.2	4.6			6300	2858			6300	2858
1/4	6.4			13.5	6.1			8200	3720			8200	3720
9/32	7.1			17.0	7.7			10,300	4672			10,300	4672
5/16	7.9			21.0	9.5			12,500	5670			12,500	5670
3/8	9.5			30.0	13.6			17,500	7938			17,500	7938

*30.5m = 100 ft

** To convert to Kilonewtons (kN), multiply tons (minimum breaking force) by 8.896;
1 lb = 4.448 newtons (N).

TABLE 34 MINIMUM BREAKING FORCE OF WIRE ROPE
7 x 7 and 7 x 19 Small Diameter Specialty Cord, Galvanized and Corrosion Resistant

Nominal Diameter		Approximate Mass				Minimum Breaking Force***							
						Galvanized				Corrosion Resistant			
		7 x 7		7 x 19		7 x 7		7 x 19		7 x 7		7 x 19	
inches	mm	lbs./ 100ft	kg/ 30.5m**	lbs./ 100ft	kg./ 30.5m**	lb	kg	lb	kg	lb	kg	lb	kg
1/32	.8	.16*	.07*			110*	49.9*			110*	49.9*		
3/64	1.2	.42	.19			270	122			270	122		
1/16	1.6	.75	.34	.75	.34	480	218	480	218	480	218	480	218
5/64	2.0	1.1	.50			650	295			650	295		
3/32	2.4	1.6	.73	1.7	.77	920	417	1000	454	920	417	920	417
7/64	2.8	2.2	1.0			1260	572			1260	572		
1/8	3.2	2.8	1.3	2.9	1.3	1700	771	2000	907	1700	771	1760	798
5/32	4.0	4.3	2.0	4.5	2.0	2600	1179	2800	1270	2400	1089	2400	1089
3/16	4.8	6.2	2.8	6.5	2.9	3700	1678	4200	1905	3700	1678	3700	1678
7/32	5.6	8.3	3.8	8.6	3.9	4800	2177	5600	2540	4800	2177	5000	2268
1/4	6.4	10.6	4.8	11.0	5.0	6100	2767	7000	3175	6100	2767	6400	2903
9/32	7.1	13.4	6.1	13.9	6.3	7600	3447	8000	3629	7600	3447	7800	3538
5/16	7.9	16.7	7.6	17.3	7.8	9200	4173	9800	4445	9000	4082	9000	4082
11/32	8.7	20.1	9.1	20.7	9.4	11,100	5035	12,500	5670	10,500	4763		
3/8	9.5	23.6	10.7	24.3	11.0	13,100	5942	14,400	6532	12,000	5443	12,000	5443

*3 x 7 construction
**30.5m = 100 ft
*** To convert to Kilonewtons (kN), multiply tons (minimum breaking force) by 8.896;
1 lb = 4.448 newtons (N).

TABLE 35 MINIMUM BREAKING FORCE OF WIRE ROPE
6 x 12 Construction/Galvanized, Fiber Core

Nominal Diameter		Approximate Mass		Minimum Breaking Force*	
				Improved Plow Steel**	
inches	mm	lb/ft	kg/m	tons	metric tonnes
5/16	7.9	0.10	0.14	2.34	2.12
3/8	9.5	0.15	0.22	3.36	3.05
7/16	11.1	0.20	0.30	4.55	4.13
1/2	12.7	0.26	0.39	5.91	4.71
9/16	14.3	0.33	0.49	7.45	6.76
5/8	15.8	0.41	0.61	9.16	8.31
3/4	19.1	0.59	0.88	13.1	11.9
13/16	20.6	0.69	1.03	15.3	13.9
7/8	22.2	0.80	1.19	17.7	16.1
1	25.4	1.05	1.56	23.0	20.9

* To convert to Kilonewtons (kN), multiply tons (minimum breaking force) by 8.896; 1 lb = 4.448 newtons (N).

**Available with galvanized wires at strengths 10% lower than listed, or at equivalent strengths on special request.

TABLE 36 MINIMUM BREAKING FORCE OF WIRE ROPE
6 x 24 Construction/Galvanized, Fiber Core

Nominal Diameter		Approximate Mass		Minimum Breaking Force* Improved Plow Steel**	
inches	mm	lb/ft	kg/m	tons	metric tonnes
3/8	9.5	0.19	0.29	4.77	4.33
1/2	12.7	0.35	0.52	8.40	7.62
9/16	14.3	0.44	0.65	10.6	9.62
5/8	15.9	0.54	0.80	13.0	11.8
3/4	19.1	0.78	1.16	18.6	16.9
7/8	22.2	1.06	1.58	25.2	22.9
1	25.4	1.38	2.05	32.8	29.8
1-1/8	28.6	1.75	2.60	41.2	37.4
1-1/4	31.8	2.16	3.21	50.7	46.0
1-3/8	34.9	2.61	3.88	61.0	55.3
1-1/2	38.1	3.11	4.63	72.3	65.6
1-5/8	41.3	3.64	5.42	84.5	76.7
1-3/4	44.5	4.23	6.30	97.5	88.5
1-7/8	47.6	4.85	7.22	111	101
2	50.8	5.52	8.21	126	114

* To convert to Kilonewtons (kN), multiply tons (minimum breaking force) by 8.896; 1 lb = 4.448 newtons (N).

**Available with galvanized wires at strengths 10% lower than listed, or at equivalent strengths on special request.

TABLE 37 MINIMUM BREAKING FORCE OF WIRE ROPE
Compacted Strand Wire Rope
6 x 19 and 6 x 36 Classification/Bright (Uncoated) FC & IWRC

Nominal Diameter		Approximate Mass				Minimum Breaking Force*			
inches	mm	lb/ft		kg/m		tons		metric tonnes	
		FC	IWRC	FC	IWRC	FC	IWRC	FC	IWRC
3/8	9.5	.26	.31	.39	.46	7.39	8.3	6.7	7.53
7/16	11.1	.35	.39	.52	.58	10.0	11.2	9.07	10.2
1/2	12.7	.46	.49	.68	.73	13.0	14.6	11.8	13.2
9/16	14.3	.57	.63	.85	.94	16.4	18.5	14.9	16.8
5/8	15.9	.71	.78	1.06	1.16	20.2	22.7	18.3	20.6
3/4	19.1	1.03	1.13	1.53	1.68	28.8	32.4	26.1	29.4
7/8	22.2	1.40	1.54	2.08	2.29	39.0	43.8	35.4	39.7
1	25.4	1.82	2.00	2.71	2.98	50.7	56.9	46.0	51.6
1-1/8	28.6	2.31	2.54	3.44	3.78	63.6	71.5	57.7	64.9
1-1/4	31.8	2.85	3.14	4.24	4.67	78.2	87.9	70.9	79.7
1-3/8	34.9	3.45	3.80	5.13	5.65	94.1	106	85.4	96.1
1-1/2	38.1	4.10	4.50	6.10	6.70	111	125	101	113
1-5/8	41.3	4.80	5.27	7.14	7.84	130	146	118	132
1-3/4	44.5	5.56	6.12	8.27	9.11	150	169	136	153
1-7/8	47.6	6.38	7.02	9.49	10.4	171	192	155	174
2	50.8	7.26	7.98	10.8	11.9	193	217	175	197

* To convert to Kilonewtons (kN), multiply tons (minimum breaking force) by 8.896;
1 lb = 4.448 newtons (N).

TABLE 38 MINIMUM BREAKING FORCE OF WIRE ROPE
Compacted Strand Wire Rope
19 Strand Rotation Resistant Classification/Bright (Uncoated)

Nominal Diameter		Approximate Mass		Minimum Breaking Force*			
				tons		metric tonnes	
inches	mm	lb/ft	kg/m	Standard	High Standard	Standard	High Standard
3/8	9.5	.31	.46	7.55	8.3	6.85	7.53
7/16	11.1	.40	.59	10.2	11.2	9.25	10.2
1/2	12.7	.54	.80	13.3	14.6	12.1	13.2
9/16	14.3	.69	1.03	16.8	18.5	15.2	16.8
5/8	15.9	.85	1.26	20.6	22.7	18.7	20.6
3/4	19.1	1.25	1.86	29.4	32.4	26.7	29.4
7/8	22.2	1.68	2.50	39.8	43.8	36.1	39.7
1	25.4	2.17	3.23	51.7	56.9	46.9	51.6
1-1/8	28.6	2.75	4.09	65.0	71.5	59.0	64.9
1-1/4	31.8	3.45	5.13	79.9	87.9	72.5	79.7
1-3/8	34.9	4.33	6.44	96.0	106.0	87.1	96.1
1-1/2	38.1	5.11	7.60	114.0	125.0	103.0	113.0

* To convert to Kilonewtons (kN), multiply tons (minimum breaking force) by 8.896; 1 lb = 4.448 newtons (N).

The given strengths for rotation resistant ropes are applicable only when a test is conducted on a new rope fixed at both ends. When the rope is in use, and one end is free to rotate, the nominal strength is reduced.

TABLE 39 MINIMUM BREAKING FORCE OF WIRE ROPE
35 x 7 Classification Compacted Strand Rotation Resistant - Category 1

Diameter		Approximate Mass		Minimum Breaking Force*			
				1960		2160	
inches	mm	lb/ft	kg/m	tons	kN	tons	kN
	10	0.33	0.50		87.6		98.3
	11	0.40	0.60		105		118
7/16		0.41	0.61	12.1		13.4	
	12	0.48	0.72		124		140
1/2		0.54	0.80	15.4		17.4	
	13	0.56	0.84		144		162
	14	0.65	0.97		168		188
9/16		0.68	1.01	19.7		22.0	
5/8		0.84	1.25	25.2		28.2	
	16	0.85	1.27		224		251
	18	1.08	1.61		274		308
	19	1.21	1.79		307		344
3/4		1.21	1.80	34.5		38.7	
	20	1.34	1.99		341		382
	22	1.62	2.40		415		466
7/8		1.65	2.45	47.2		53.0	
	24	1.92	2.86		491		555
1		2.15	3.21	62.4		70.0	
	26	2.26	3.36		588		660
	28	2.62	3.90		676		758
1 1/8		2.73	4.06	77.5		86.9	
1 1/4		3.37	5.01	98.1		110	
	32	3.42	5.09		873		980
1 3/8		4.07	6.06	117		124	
	36	4.33	6.44		1110		1232
1 1/2		4.85	7.21	138		147	
	40	5.34	7.95		1390		1521
1 5/8		5.69	8.47	167		182	

* To convert to Kilonewtons (kN), multiply tons (minimum breaking force) by 8.896;

TABLE 40 MINIMUM BREAKING FORCE OF WIRE ROPE
6 x 19 Classification, Elevator Ropes, Bright (Uncoated) Fiber Core

Nominal Diameter		Approximate Mass		Minimum Breaking Force-Pounds*		
inches	mm	lb/ft	kg/m	Iron	Traction	Extra High Strength Traction
1/4	6.4	.10	.15	2,200	3,600	5,200
5/16	7.9	.16	.24	3,200	5,600	8,100
3/8	9.5	.23	.34	5,000	8,200	11,600
7/16	11.1	.31	.46	6,400	11,000	15,700
1/2	12.7	.40	.60	8,400	14,500	20,400
9/16	14.3	.51	.76	10,600	18,500	25,700
5/8	15.9	.63	.94	12,800	23,000	31,600
11/16	17.5	.76	1.13	15,500	27,000	38,200
3/4	19.1	.90	1.34	18,200	32,000	45,200
13/16	20.6	1.06	1.58	21,500	37,000	52,900
7/8	22.2	1.23	1.83	24,800	42,000	61,200
15/16	23.8	1.41	2.10	28,500	48,000	70,000
1	25.4	1.60	2.38	32,000	54,000	79,500

* 1 lb = 4.448 newtons (N).

TABLE 41 MINIMUM BREAKING FORCE OF WIRE ROPE
8 x 19 Classification, Elevator Ropes, Bright (Uncoated) Fiber Core

Nominal Diameter		Approximate Mass		Minimum Breaking Force-Pounds*		
inches	mm	lb/ft	kg/m	Iron	Traction	Extra High Strength Traction
1/4	6.4	.09	.14	1,800	3,600	4,500
5/16	7.9	.14	.21	2,900	5,600	6,900
3/8	9.5	.20	.30	4,200	8,200	9,900
7/16	11.1	.28	.42	5,600	11,000	13,500
1/2	12.7	.36	.54	7,200	14,500	17,500
9/16	14.3	.46	.68	9,200	18,500	22,100
5/8	15.9	.57	.84	11,200	23,000	27,200
11/16	17.5	.69	1.03	13,400	27,000	32,800
3/4	19.1	.82	1.22	16,000	32,000	38,900
13/16	20.6	.96	1.43	18,600	37,000	46,000
7/8	22.2	1.11	1.65	21,400	42,000	52,600
15/16	23.8	1.27	1.89	24,600	48,000	60,000
1	25.4	1.45	2.16	28,000	54,000	68,400

* 1 lb = 4.448 newtons (N).

TABLE 42 MINIMUM BREAKING FORCE OF WIRE ROPE
Compacted (Swaged) Wire Rope
6 x 19 and 6 x 37 Classification/Bright (Uncoated), IWRC

Nominal Diameter		Approximate Mass		Minimum Breaking Force*	
inches	mm	lb/ft	kg/m	tons	metric tonnes
1/2	12.7	0.55	0.82	15.5	14.0
9/16	14.3	0.70	1.04	19.6	17.8
5/8	15.9	0.87	1.29	24.2	22.0
3/4	19.1	1.25	1.86	34.9	31.7
7/8	22.2	1.70	2.53	47.4	43.0
1	25.4	2.22	3.30	62.0	56.3
1-1/8	28.6	2.80	4.16	73.5	66.7
1-1/4	31.8	3.40	5.05	90.0	81.8
1-3/8	34.9	4.20	6.24	106	96.2
1-1/2	38.1	5.00	7.43	130	118

* To convert to Kilonewtons (kN), multiply tons (minimum breaking force) by 8.896;
1 lb = 4.448 newtons (N).

Appendix A

ORDERING, STORING AND UNREELING WIRE ROPE

A. *Ordering*

When ordering wire rope, it must be described as completely as possible. The generally accepted nomenclature, defined elsewhere in this publication, should be carefully noted. This, along with other applicable information will not only enable the rope supplier to satisfy the purchaser's requests, but will also provide data for technical advice or suggestions.

Following, is a check list for ordering:

1) The application or use intended for the wire rope.
2) Requirements for the rope:
   Length—standard or tape measured
   Diameter—nominal diameter
   Construction—e.g. "6 x 19 Seale"
   Preformed or non-preformed
   Lay—Right or Left; Regular or Lang Lay
   Finish—bright, galvanized, or other
   Grade—e.g., improved plow steel, traction steel, or other
   Core—independent wire rope, wire strand, or fiber
   Lubrication—Standard or special
3) Specification requirements (i.e. API, ASTM)
4) Special testing requirements and certification
5) Specify end terminations if required
6) Describe special spooling or reel requirements

B. *Storing*

No matter how the delivered rope is packaged, it should always be kept away from moisture. This means storing under a weatherproof cover, and no direct contact with the ground or floor. Ocean spray, acid fumes, or similarly corrosive atmospheres should be avoided. When reels will remain stored for long periods, the supplier should be asked to ship the ropes with a protective wrapping. Where this has not been done, the outer layers of rope should be coated with an approved lubricant.

When a rope is to be removed from service and stored, it should be thoroughly cleaned, lubricated, and carefully spooled on a reel. In this case, the same storage conditions that are required for new rope should be maintained.

Ambient temperature for rope in storage should be low. Elevated temperatures tend to liquefy or thin out rope lubricants. Thus, wire rope storage areas should not only be normally cool spaces, but possible sources of high heat should be kept at some distance.

Appendix A

C. *Unreeling*

Wire rope must always be handled with care. This is particularly important when reels or coils are received, moved about, unreeled or uncoiled. Reels or coils should never be dropped. When this happens, the rope may shift and cause the reel to collapse and thus the rope itself may be damaged. Removing rope from a collapsed reel may often result in rope damage. Coiled rope, if dropped on the edge of the coil, can sustain a permanent bend.

Coils and reels should only be rolled on relatively smooth, hard surfaces. Rolling through loose dirt, standing water, or across sharp, hard objects, or over uneven surfaces can cause deformations or harm the lubricant protection.

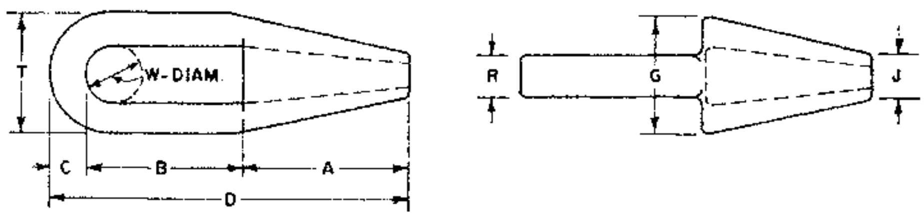
Careful handling before installation and proper maintenance procedures afterward will ensure the longest possible service life for wire rope.

Improper handling can prove quite costly for the user, yet, for the most part, abuse is easily avoidable.

Appendix B WIRE ROPE FITTINGS

CLOSED WIRE ROPE SPELTER SOCKETS

TABLE 43 DIMENSIONS (inches)



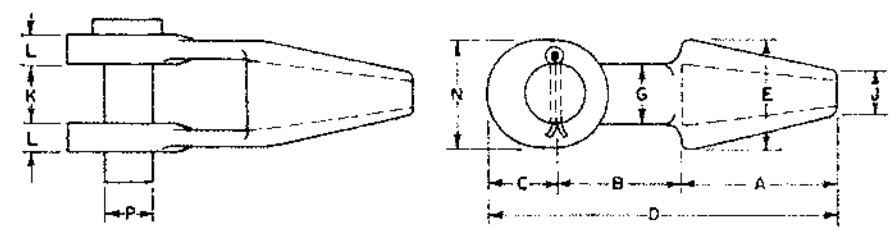
Rope Diam.	A	B	C	D	G	J	R	T	W	Approx. Wt Lb
3/16 – 1/4	2	1 3/4	7/16	4 3/16	1 5/16	9/16	1/2	1 7/16	13/16	0.5
5/16 – 3/8	2	2	9/16	4 9/16	1 9/16	3/4	5/8	1 11/16	15/16	0.9
7/16 – 1/2	2 1/2	2 1/4	11/16	5 7/16	1 7/8	15/16	7/8	2	1 1/8	1.5
9/16 – 5/8	3	2 1/2	13/16	6 5/16	2 3/8	1 1/8	1	2 5/8	1 3/8	3.0
3/4	3 1/2	3	1 1/16	7 5/8	2 3/4	1 1/4	1 1/4	3	1 5/8	4.5
7/8	4	3 1/2	1 1/4	8 7/8	3 1/4	1 1/2	1 1/2	3 5/8	1 7/8	7.
1	4 1/2	4	1 3/8	9 7/8	3 3/4	1 3/4	1 3/4	4 1/8	2 1/4	11.
1 1/8	5	4 1/2	1 1/2	11	4 1/8	2	2	4 1/2	2 1/2	16.
1 1/4 – 1 3/8	5 1/2	5	1 5/8	12 1/8	4 3/4	2 1/4	2 1/4	5	2 3/4	22.
1 1/2	6	6	1 15/16	13 15/16	5 1/4	2 3/4	2 1/2	5 3/8	3 1/8	28.
1 5/8	6 1/2	6 3/4	2 1/8	15 3/8	5 1/2	3	2 3/4	5 3/4	3 1/4	36.
1 3/4 – 1 7/8	7 1/2	7 13/16	2 3/16	17 1/2	6 3/8	3 1/8	3	6 3/4	3 17/32	58.
2 – 2 1/8	8 1/2	8 13/16	2 7/16	19 3/4	7 3/8	3 3/4	3 1/4	7 5/8	3 25/32	80.
2 1/4 – 2 3/8	9	9 3/4	2 7/8	21 5/8	8 1/4	4	3 5/8	8 1/2	4 9/32	105.
2 1/2 – 2 5/8	9 3/4	10 5/8	3 1/8	23 1/2	9 1/4	4 1/2	4	9 1/2	4 25/32	140.
2 3/4 – 2 7/8	11	11 1/2	3	25 1/2	10 3/4	4 7/8	4 7/8	10 3/4	5 1/32	220.
3 – 3 1/8	12	11 3/4	3 1/4	27	11 1/2	5 1/4	5 1/4	11 1/2	5 9/32	276.
3 1/4 – 3 3/8	13	12 1/4	4	29 1/4	12 1/4	5 3/4	5 3/4	12 1/4	5 17/32	276.
3 1/2 – 3 5/8	14	13	4	31	13	6 1/2	6 1/4	13	6 1/32	400.
3 3/4 – 4	15	14	4 1/4	33 1/4	14 1/4	7 1/4	7	14 1/4	7 1/32	540.

Note: Dimensions are for reference only. Consult your supplier of the specific fittings for exact details.

Appendix B

OPEN WIRE ROPE
SPELTER SOCKETS

TABLE 44 DIMENSIONS (inches)



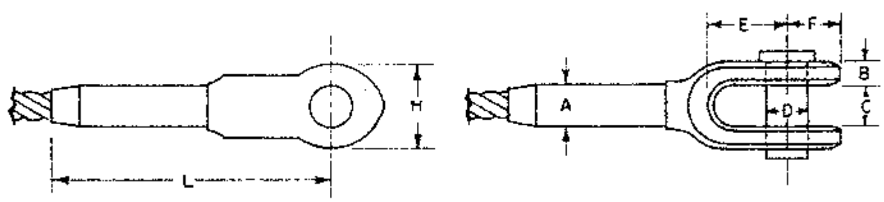
Rope Diam.	A	B	C	D	E	G	J	K	L	N	P	Approx. Wt Lb
3/16 – 1/4	2	1 9/16	3/4	4 5/16	1 5/16	3/4	9/16	11/16	5/16	1 5/16	11/16	0.9
5/16 – 3/8	2	1 3/4	7/8	4 5/8	1 9/16	13/16	3/4	13/16	13/32	1 1/2	13/16	1.1
7/16 – 1/2	2 1/2	2	1 1/16	5 9/16	1 7/8	1	15/16	1	1/2	1 7/8	1	2.3
9/16 – 5/8	3	2 1/2	1 1/4	6 3/4	2 1/4	1 1/4	1 1/8	1 1/4	9/16	2 1/4	1 3/16	3.8
3/4	3 1/2	3	1 7/16	7 15/16	2 5/8	1 1/2	1 1/4	1 1/2	5/8	2 5/8	1 3/8	6.
7/8	4	3 1/2	1 3/4	9 1/4	3 1/8	1 3/4	1 1/2	1 3/4	3/4	3 1/8	1 5/8	10.
1	4 1/2	4	2 1/16	10 9/16	3 5/8	2	1 3/4	2	7/8	3 3/4	2	15.
1 1/8	5	4 1/2	2 5/16	11 13/16	4	2 3/8	2	2 1/4	1	4 1/8	2 1/4	23.
1 1/4 – 1 3/8	5 1/2	5	2 11/16	13 3/16	4 5/8	2 3/4	2 1/4	2 1/2	1 1/8	4 3/4	2 1/2	32.
1 1/2	6	6	3 1/8	15 1/8	5 1/4	3	2 3/4	3	1 3/16	5 3/8	2 3/4	47.
1 5/8	6 1/2	6 1/2	3 1/4	16 1/4	5 1/2	3 1/4	3	3	1 5/16	5 3/4	3	55.
1 3/4 – 1 7/8	7 1/2	7	3 3/4	18 1/4	6 3/8	3 7/8	3 1/8	3 1/2	1 9/16	6 1/2	3 1/2	85.
2 – 2 1/8	8 1/2	9	4	21 1/2	7 3/8	4 1/4	3 3/4	4	1 13/16	7	3 3/4	125.
2 1/4 – 2 3/8	9	10	4 1/2	23 1/2	8 1/4	4 3/8	4	4 1/2	2 1/8	7 3/4	4 1/4	165.
2 1/2 – 2 5/8	9 3/4	10 3/4	5	25 1/2	9 1/4	4 5/8	4 1/2	5	2 3/8	8 1/2	4 3/4	252.
2 3/4 – 2 7/8	11	11	5 1/4	27 1/4	10 3/4	4 7/8	4 7/8	5 1/4	2 7/8	9	5	315.
3 – 3 1/8	12	11 1/4	5 3/4	29	11 1/2	5 1/4	5 1/4	5 3/4	3	9 1/2	5 1/4	380.
3 1/4 – 3 3/8	13	11 3/4	6 1/8	30 7/8	12 1/4	5 3/4	5 3/4	6 1/4	3 1/8	10	5 1/2	434.
3 1/2 – 3 5/8	14	12 1/2	6 3/4	33 1/4	13	6 1/4	6 1/2	6 3/4	3 1/4	10 3/4	6	563.
3 3/4 – 4	15	13 1/2	7 3/4	36 1/4	14 1/4	7	7 1/4	7 1/2	3 1/2	12 1/2	7	783.

Note: Dimensions are for reference only. Consult your supplier of the specific fittings for exact details.

Appendix B

OPEN WIRE ROPE SWAGED SOCKETS

TABLE 45 DIMENSIONS (inches)



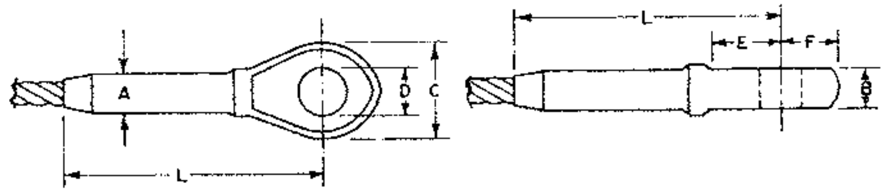
Rope diam.	After Swaging A	B	Jaw opening C	Pin diam. D	E	F	H	L	Approx. wt/lb
1/4	7/16	3/8	11/16	11/16	1 1/2	13/16	1 3/8	4	.52
5/16	11/16	15/32	13/16	13/16	1 3/4	15/16	1 5/8	5 5/16	1.12
3/8	11/16	15/32	13/16	13/16	1 3/4	15/16	1 5/8	5 5/16	1.07
7/16	7/8	9/16	1	1	2	1 1/8	2	6 11/16	2.08
1/2	7/8	9/16	1	1	2	1 1/8	2	6 11/16	2.08
5/8	1 1/8	19/32	1 1/4	1 3/16	2 1/4	1 3/8	2 3/8	8 1/8	4.28
3/4	1 3/8	21/32	1 1/2	1 3/8	2 3/4	1 9/16	2 3/4	10	7.97
7/8	1 1/2	3/4	1 3/4	1 5/8	3 1/4	1 25/32	3 1/8	11 5/8	11.3
1	1 3/4	7/8	2	2	3 3/4	2 3/32	3 11/16	13 3/8	17.8
1 1/8	2	1	2 1/4	2 1/4	4 1/4	2 5/16	4 1/16	15	26.0
1 1/4	2 1/4	1 1/8	2 1/2	2 1/2	4 3/4	2 9/16	4 1/2	16 1/2	34.9
1 3/8	2 1/2	1 1/8	2 1/2	2 1/2	5 1/4	2 13/16	5	18 1/8	44.4
1 1/2	2 3/4	1 3/16	3	2 3/4	5 3/4	3 1/8	5 1/2	19 3/4	58.0
1 3/4	3	1 9/16	3 1/2	3 1/2	6 3/4	3 5/8	6 1/4	23	87.5
2	3 1/2	1 61/64	4	3 3/4	8	4 9/16	8	26 7/8	150

Note: Dimensions are for reference only. Consult your supplier of the specific fittings for exact details.

Appendix B

CLOSED WIRE ROPE SWAGED SOCKETS

TABLE 46 DIMENSIONS (inches)



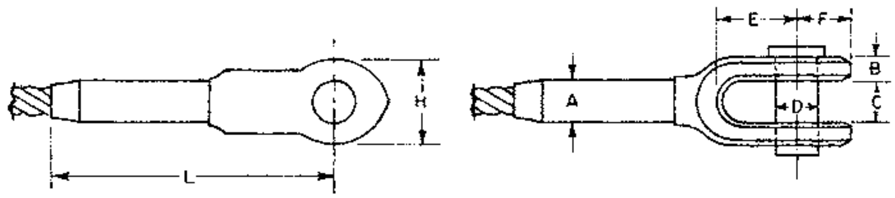
Rope diam.	After Swaging A	Eye thickness B	C	Hole diam. D	E	F	L	Approx. wt (lb)
1/4	7/16	1/2	1 3/8	3/4	1 3/8	13/16	3 1/2	.32
5/16	11/16	43/64	1 5/8	7/8	1 5/16	15/16	4 1/2	.77
3/8	11/16	43/64	1 5/8	7/8	1 5/16	15/16	4 1/2	.72
7/16	7/8	55/64	2	1 1/16	1 1/2	1 5/32	5 3/4	1.42
1/2	7/8	55/64	2	1 1/16	1 1/2	1 5/32	5 3/4	1.35
5/8	1 1/8	1 1/8	2 3/8	1 1/4	1 15/16	1 3/8	7 1/4	2.85
3/4	1 3/8	1 5/16	2 7/8	1 7/16	2 1/4	1 21/32	8 5/8	4.90
7/8	1 1/2	1 1/2	3 1/8	1 11/16	2 11/16	1 13/16	10 1/8	7.28
1	1 3/4	1 3/4	3 5/8	2 1/16	3	2 1/16	11 1/2	10.3
1 1/8	2	2	4	2 5/16	3 3/16	2 9/32	12 3/4	14.4
1 1/4	2 1/4	2 1/4	4 1/2	2 9/16	3 3/4	2 9/16	14 3/8	21.4
1 3/8	2 1/2	2 1/4	5	2 9/16	4 1/16	2 7/8	15 3/4	27.9
1 1/2	2 3/4	2 1/2	5 1/2	2 13/16	4 1/4	3 1/8	17	36.0
1 3/4	3	3	6 1/4	3 9/16	5 1/8	3 9/16	20	51.0
2	3 1/2	3 1/4	7 3/4	3 13/16	6	4 5/8	23	90.0

Note: Dimensions are for reference only. Consult your supplier of the specific fittings for exact details.

Appendix B

OPEN STRAND SWAGED SOCKETS

TABLE 47 DIMENSIONS FOR 19-WIRE AND 37-WIRE STRAND SOCKETS (inches)



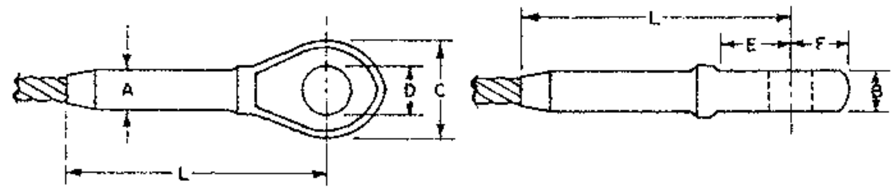
Strand diam.	A	B	Jaw opening C	Pin diam. D	E	F	H	L	Approx. wt/lb without Pin
1/2 – 9/16	1 1/8	5/8	1 1/4	1 3/16	2 1/4	1 7/16	2 1/2	8 3/4	3.5
5/8	1 3/8	3/4	1 1/2	1 3/8	2 3/4	1 11/16	3	10 1/2	6.25
11/16 – 3/4	1 1/2	15/16	1 3/4	1 5/8	3 1/4	2	3 3/8	12 1/4	9.25
13/16 – 7/8	1 3/4	1 1/32	2	2	3 3/4	2 1/4	4	14	14.5
15/16 – 1	2	1 3/16	2 1/4	2 1/4	4 1/4	2 9/16	4 1/2	15 3/4	20.5
1 1/16 – 1 1/8	2 1/4	1 3/16	2 1/2	2 1/2	4 3/4	2 15/16	5	17 1/2	29.25
1 3/16 – 1 1/4	2 1/2	1 5/16	2 1/2	2 1/2	5 1/4	3 1/8	5 1/4	19 1/4	38.25
1 5/16 – 1 3/8	2 3/4	1 7/16	3	2 3/4	5 3/4	3 1/2	5 3/4	21	45.0

Note: Dimensions are for reference only. Consult your supplier of the specific fittings for exact details.

Appendix B

CLOSED STRAND SWAGED SOCKETS

TABLE 48 DIMENSIONS FOR 19-WIRE AND 37-WIRE STRAND (inches)



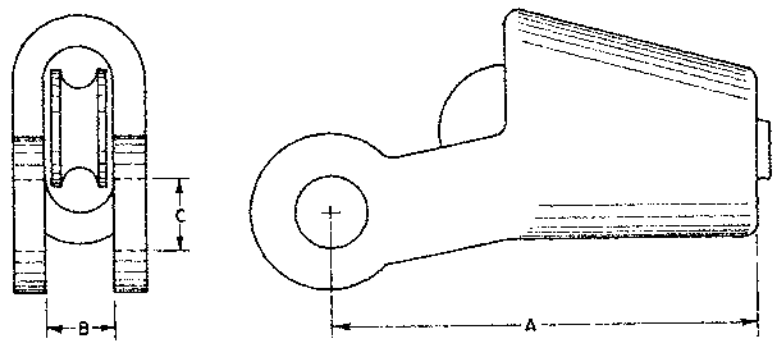
Strand diam.	A	Eye thickness B	Hole diam. C	D	E	F	L	Approx. wt (lb)
1/2 – 9/16	1 1/8	1 1/8	2 1/2	1 1/4	2 1/8	1 7/16	7 1/2	2.75
5/8	1 3/8	1 5/16	3	1 15/32	2 5/8	1 3/4	9	5.0
11/16 – 3/4	1 1/2	1 1/2	3 1/2	1 23/32	3 1/8	2	11	7.25
13/16 – 7/8	1 3/4	1 3/4	4	2 3/32	3 3/8	2 1/4	12 1/2	11.0
15/16 – 1	2	2	4 1/2	2 11/32	3 3/4	2 1/2	13 1/2	16.0
1 1/16 – 1 1/8	2 1/4	2 1/4	5	2 19/32	4 1/4	2 7/8	15	23.0
1 3/16 – 1 1/4	2 1/2	2 1/4	5 1/4	2 19/32	4 1/2	3 1/8	16 1/2	29.0
1 5/16 – 1 3/8	2 3/4	2 1/2	5 1/2	2 7/8	4 3/4	3 3/8	18	35.5

Note: Dimensions are for reference only. Consult your supplier of the specific fittings for exact details.

Appendix B

OPEN WIRE ROPE
WEDGE-TYPE SOCKETS

TABLE 49 DIMENSIONS OF SOCKETS (inches)



Diameter of rope	Center of pin hole to end of socket A	Opening between ears B	Diameter of pin hole C	Approximate wt (lb)
3/8	4 3/4	5/8	13/16	2.5
1/2	5 1/2	5/8	1 1/16	2.5
5/8	7	1 1/4	1 3/16	5
3/4	7 1/2	1 3/8	1 1/4	9
7/8	9	1 1/2	1 5/8	15
1	9 3/4	1 5/8	1 5/8	20
1 1/8	10 5/8	1 5/8	1 5/8	23
1 1/4	11 3/4	1 3/4	2 1/8	32
1 3/8	11 3/4	1 3/4	2 1/8	32
1 1/2	13 1/4	2 1/2	3 1/8	52
1 5/8	13 1/4	2 1/2	3 1/8	52

Note:.Dimensions are for reference only. Consult your supplier of the specific fittings for exact details.

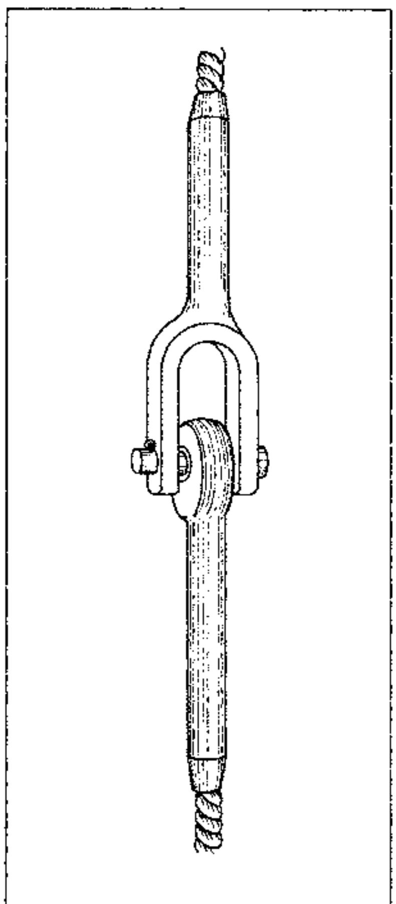
Appendix B

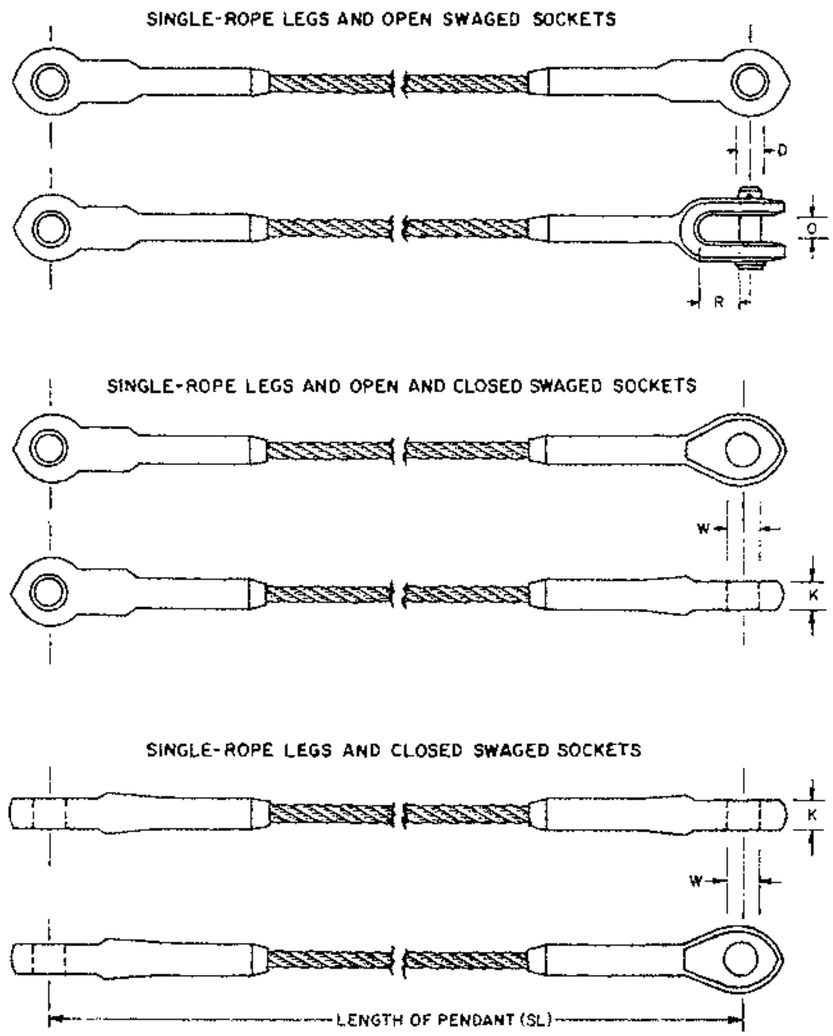
WIRE ROPE ASSEMBLIES

When ordering wire rope with end attachments, lengths—as shown on this and the following two pages — should be specified. Additionally, the load at which this measurement is taken should be specified, i.e., at no load, at a percentage of minimum breaking force, etc.

The drawings on this and the following two pages do not show all possible combinations of fittings; in any case, the same measuring methods should be followed.

BOOM PENDANTS WITH SWAGED FITTINGS





BOOM PENDANTS WITH SWAGED FITTINGS

Length of Pendant is measured as indicated on sketches.

Note: When ordering, customer should specify parallel or right angle (90°) socket pins.

Appendix B

a

Closed wire rope spelter socket at one end; open wire rope spelter socket at other end.
Measurement: Pull of closed socket to centerline of open socket pin.

---

b

Closed wire rope swaged socket at one end; open wire rope swaged socket at other end.
Measurement: Centerline of pin to centerline of pin.

---

c

Closed bridge socket attached to one end: open bridge socket attached to other end.
Measurements: Centerline of closed socket pin to centerline of open socket pin; include two of the three values: takeup, contraction, and expansion. The values of C and O are also required.

---

d

Thimble spliced at one end.
Measurement: Pull of thimble to end of rope.

---

e

Link spliced at one end; hook spliced at other end.
Measurement: Pull of link to pull of hook.

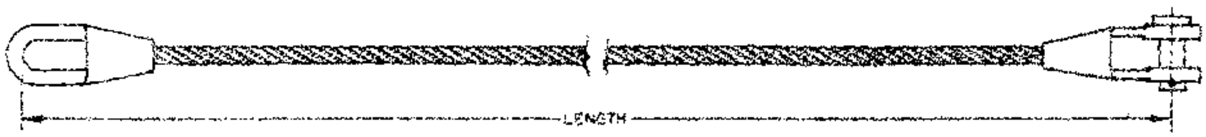
---

f

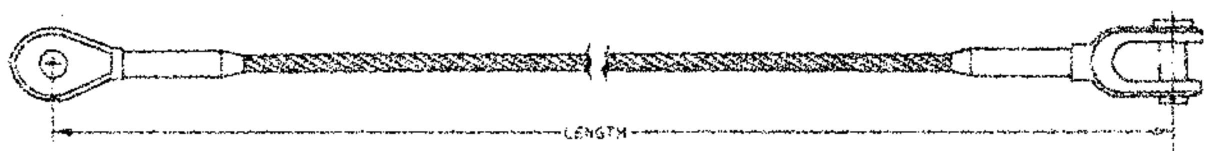
Thimble spliced at one end; loop spliced at other end.
Measurements: Pull of thimble to pull of loop, and circumference of loop.

Appendix B

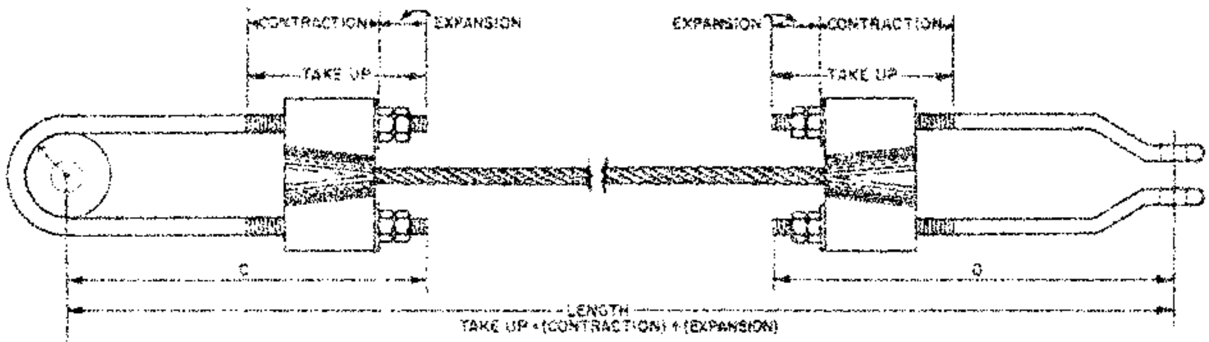
a



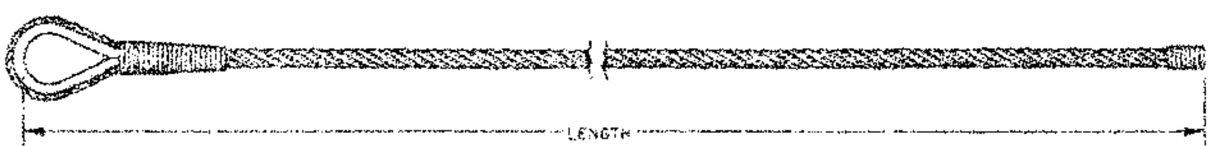
b



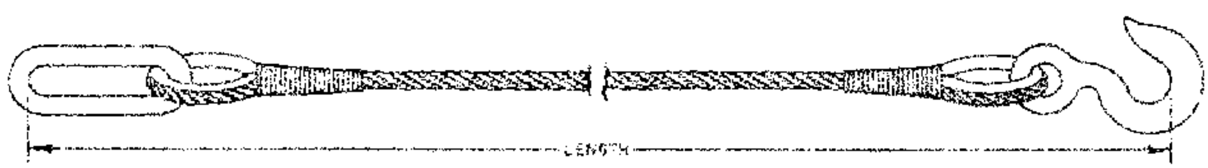
c



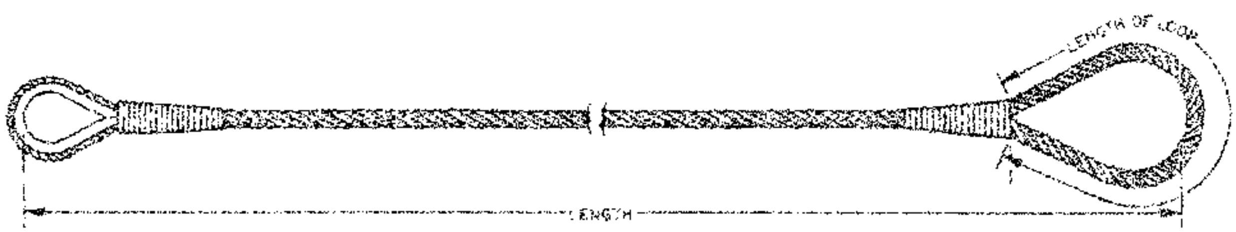
d



e



f



Appendix B

TABLE 50 RATED CAPACITIES IN TONS OF 2,000 LB.
6 x 19 & 6 x 37 IWRC IMPROVED PLOW STEEL*

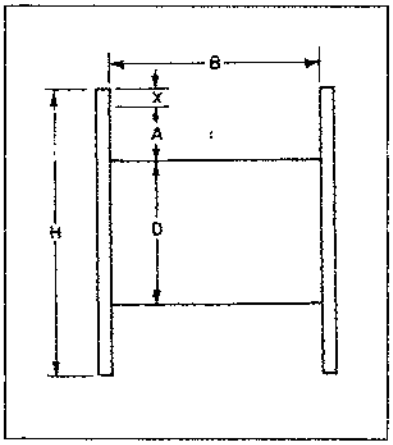
Diam. of rope (inches)	Min. Length (SL) of pendant ft-inches	Single part vertical	Two Pendants When Used		Open Swaged Socket**				Closed Swaged Socket**		
			30°	45°	O inches	D inches	R inches	Weight lb	K inches	W inches	Weight lb
1/4	0-11	0.59	1.0	0.83	11/16	11/16	1 5/32	.52	1/2	3/4	.32
3/8	1-3	1.3	2.3	1.8	13/16	13/16	1 11/32	1.07	43/64	7/8	.72
1/2	1-8	2.3	4.0	3.2	1	1	1 1/2	2.08	55/64	1 1/16	1.35
5/8	2-0	3.6	6.2	5.1	1 1/4	1 3/16	1 21/32	4.28	1 1/8	1 1/4	2.85
3/4	2-5	5.1	8.9	7.2	1 1/2	1 3/8	2 1/16	7.97	1 5/16	1 7/16	4.90
7/8	2-10	6.9	12	9.8	1 3/4	1 5/8	2 7/16	11.3	1 1/2	1 11/16	7.28
1	3-2	9.0	15	13	2	2	2 3/4	17.8	1 3/4	2 1/16	10.3
1 1/8	3-7	11	19	16	2 1/4	2 1/4	3 1/8	26.0	2	2 5/16	14.4
1 1/4	4-0	14	24	20	2 1/2	2 1/2	3 1/2	34.9	2 1/4	2 9/16	21.4
1 3/8	4-5	17	29	23	2 1/2	2 1/2	4	44.4	2 1/4	2 9/16	27.9
1 1/2	4-9	20	34	28	3	2 3/4	4 3/8	58.0	2 1/2	2 13/16	36.0
1 3/4	5-5	27	46	38	3 1/2	3 1/2	5	87.5	3	3 9/16	51.0
2	6-4	34	60	49	4	3 3/4	6 1/8	150	3 1/4	3 13/16	90.0

* Values given apply when pendants are used as slings or sling assemblies. When used in a Boom suspension system, other values apply; consult rope manufacturer.

** Dimension symbols (O,D,R,K & W) are described in drawings on pages 128 and 129.

SHIPPING REEL CAPACITY

While it is virtually impossible to calculate the precise length of wire rope that can be spooled on a reel or drum, the following formula provides a close approximation.



The formula is: $L = (A+D) \cdot A \cdot B \cdot K$

Where: L = length of rope (ft)
A = depth of rope space on drum (inches)
B = width of drum between flanges (inches)
D = drum barrel diameter (inches)
K = constant for given rope diameter (see table below)
H = diameter of reel flanges (inches)
X = clearance

TABLE 51 "K" FACTORS*

(0.2618/rope diameter squared)**

Diam. (inches)	K	Diam. (inches)	K	Diam. (inches)	K
1/16	56.9	1/2	.950	1-3/8	.126
3/32	25.4	9/16	.749	1-1/2	.106
1/8	14.4	5/8	.608	1-5/8	.0900
5/32	9.38	11/16	.502	1-3/4	.0775
3/16	6.48	3/4	.422	1-7/8	.0675
7/32	4.59	13/16	.360	2	.0594
1/4	3.73	7/8	.310	2-1/8	.0521
5/16	2.39	1	.237	2-1/4	.0469
3/8	1.69	1-1/8	.188	2-3/8	.0421
7/16	1.24	1-1/4	.152	2-1/2	.0380

* The values given for "K" factors take maximum allowable rope oversize into account. (See Table 3, page 26). These "K" factor values do not apply to certain special ropes such as aircraft cords and elevator ropes. Clearance ("X") should be about 2 inches unless rope-end fittings require more.

**This formula is based on uniform rope winding on the reel. It will not give correct results if the winding is non-uniform. The formula also assumes that there will be the same number of wraps of rope in each layer. While this is not strictly correct, there is no appreciable error in the result unless the traverse of the reel is quite small relative to the flange diameter ("H").

Appendix D A GLOSSARY OF WIRE ROPE TERMS

ABRASION Frictional surface wear on the wires of a wire rope.

ACCELERATION STRESS The additional stress that is imposed on a wire rope as a result of an increase in the load velocity.

AGGREGATE STRENGTH The calculated strength derived by totalling the individual breaking strengths of the elements of the strand or rope. This strength does not give recognition to the reduction in strength resulting from the angularity of the elements in the rope, or other factors that may affect efficiency.

AIRCRAFT CABLES Strands, cords and wire rope made of special-strength wire, designed primarily for use in various aircraft industry applications.

ALTERNATE LAY See LAY, TYPES.

AREA, METALLIC Sum of the cross-sectional areas of all the wires either in a wire rope or in a strand.

BACK-STAY Wire rope or strand guy used to support a boom or mast; or that section of a main cable, as on a suspension bridge, cableway, etc., leading from the tower to the anchorage.

BAIL a) U-shaped member of a bucket, or b) U-shaped portion of a socket or other fitting used on wire rope.

BASKET OF SOCKET The conical portion of a socket into which a broomed-rope-end is inserted and then secured.

BECKET An end attachment to facilitate wire rope installation.

BECKET LOOP A loop of small rope or strand fastened to the end of a larger wire rope; its function is to facilitate wire rope installation.

BENDING STRESS Stress that is imposed on the wires of a strand or rope by a bending or curving action.

BIRDCAGE A colloquialism descriptive of the appearance of a wire rope forced into compression. The outer strands form a *cage* and, at times, displace the core.

BLOCK A term applied to one or more wire rope sheaves (pulleys) enclosed in side plates and fitted with some attachment such as a hook or shackle.

BOOM HOIST LINE Wire rope that operates the boom hoist system of derricks, cranes, draglines, shovels, etc.

BOOM PENDANT A non-operating rope or strand with end terminations to support the boom.

BREAKING FORCE

Breaking force is the ultimate load at which a tensile failure occurs in the sample of wire rope being tested.

Minimum Acceptance Strength is that strength which is 2-1/2% lower than the nominal strength. This tolerance is used in some specifications (i.e. RR-W-410) to offset variables that occur during sample preparation and actual physical test of a wire rope.

Minimum Breaking Force (Nominal Strength in RR-W-410) is the published strength calculated by a standard procedure that is accepted by the wire rope industry. The wire rope manufacturer designs wire rope to this value, and the user should consider this value when making design calculations.

BRIDGE CABLE (Structural Rope or Strand) The all-metallic wire rope or strand used as the catenary and suspenders on a suspension bridge.

BRIDGE SOCKET A wire rope or strand end termination made of forged or cast steel that is designed with baskets--having adjustable bolts—for securing rope ends. There are two styles: 1) the *closed type* has a U-bolt with or without a spool in the U of the bolt, and 2) the *open type* has two eye-bolts and a pin.

BRIDLE SLING A multi-leg wire rope SLING.

BRIGHT ROPE Wire rope fabricated from wires that are not coated.

BULL WHEEL A term applied to a large-diameter wire rope SHEAVE, e.g., the sheaves at the end of a ski lift.

BUTTON CONVEYOR ROPE Wire rope to which buttons or discs are attached at regular intervals to move material as in a trough.

CABLE A term loosely applied to wire rope, wire strand and electrical conductors.

CABLE-LAID WIRE ROPE A type of wire rope consisting of several wire ropes laid into a single wire rope (e.g., 6 x 42 (6 x 6 x 7) tiller rope).

CABLE TOOL DRILLING LINE The wire rope used to operate the cutting tools in the cable tool drilling method (i.e., rope drilling).

CABLEWAY Aerial conveying system for transporting single loads along a suspended track cable.

CASING LINE Wire rope used to install oil well casings.

CATENARY A curve formed by a strand or wire rope when supported horizontally between two fixed points. e.g., the main spans on a suspension bridge.

CENTER The axial member of a strand about which the wires are laid.

CHANGE OF LAYER POINT That point in the traverse of a rope across the face of the drum where it reaches the flange, reverses direction and begins forming the next layer. Also referred to as the drum cross-over or TURN-BACK POINT.

CHOKER ROPE A short wire rope sling that forms a slip noose around an object that is to be moved or lifted.

CIRCUMFERENCE Measured perimeter of a circle that circumscribes either the wires of a strand, or the strands of a wire rope.

CLASSIFICATION Group, or family designation based on wire rope constructions with common strengths and weights listed under the broad designation.

CLEVIS See SHACKLE.

CLIP Fitting for clamping two parts of wire rope to each other.

CLOSED SOCKET A wire rope end termination consisting of basket and bail made integral.

CLOSER A machine that lays strands around a core to form rope.

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CLOSING LINE Wire rope that performs two functions: 1) closes a clamshell or orange peel bucket, and 2) operates as a hoisting rope.

COIL Circular bundle or package of wire rope that is not affixed to a reel.

CONSTRUCTION Geometric design description of the wire rope's cross section. This includes the number of STRANDS, the number of WIRES per strand and the pattern of wire arrangement in each STRAND.

CONSTRUCTIONAL STRETCH The stretch that occurs when the rope is initially loaded—it is due to the helically laid wires and strands creating a constricting action that compresses the core and generally brings all of the rope's elements into close contact.

CONTINUOUS BEND Reeving of wire rope over sheaves and drums so that it bends in one direction, as opposed to REVERSE BEND.

CONVEYOR ROPE Endless wire rope used to carry material.

CORD Term applied to small diameter specialty wire rope or strand.

CORE The axial member of a wire rope around which the strands are laid.

CORING LINE Wire rope used to operate the coring tool that is used to take core samples during oil well drilling.

CORROSION Chemical decomposition of the wires in a rope through the action of moisture, acids, alkalines or other destructive agents.

CORROSION RESISTING STEEL Chrome-nickel steel alloys designed for increased resistance to corrosion.

CORRUGATED Term used to describe the grooves of a SHEAVE or DRUM after they have been worn down to a point where they show an impression of a wire rope.

CREEP The unique movement of a wire rope with respect to a drum surface or sheave surface resulting from the asymmetrical load between one side of the sheave (drum) and the other. It should be distinguished from slip which is yet another type of relative movement between rope and the sheave or drum surface.

CROSS LAY See LAY, TYPES.

CROWD ROPE A wire rope used to drive or force a shovel bucket into the material that is to be handled.

DEAD LINE In drilling, it is the end of the rotary drilling line fastened to the anchor or dead-line clamp.

DECELERATION STRESS The additional stress that is imposed on a wire rope as a result of a decrease in the load velocity.

DEFLECTION a) The sag of a rope in a span. Usually measured at mid-span as the depth from the chord joining the tops of the two supports. b) Any deviation from a rope operating in a straight line.

DESIGN FACTOR In a wire rope, it is the ratio of the minimum breaking force to the total working load.

DIAMETER As related to wire rope it is the diameter of a circle which circumscribes the wire rope.

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DOGLEG Permanent bend or deformation, in a wire rope, caused by improper use or handling.

DRAGLINE a) Wire rope used for pulling excavating or drag buckets, and b) name applied to a specific type of excavator.

DRUM A cylindrical barrel, either of uniform or tapering diameter, on which rope is wound either for operation or storage; its surface may be smooth or grooved.

EFFICIENCY (ROPE) Ratio of a wire rope's actual breaking strength and the aggregate strength of all individual wires tested separately—usually expressed as a percentage.

ELASTIC LIMIT Stress value above which permanent deformation will take place within the material.

ELONGATION See STRETCH.

END PREPARATION The treatment of the end of a length of wire rope designed primarily as an aid for pulling the rope through a reeving system or tight drum opening. Unlike END TERMINATIONS, these are not designed for use as a method for making a permanent connection.

END TERMINATION The treatment at the end or ends of a length of wire rope, usually made by forming an eye or attaching a fitting and designed to be the permanent end termination on the wire rope that connects it to the load.

ENDLESS ROPE Rope with ends spliced together to form a single continuous loop.

EQUALIZING SHEAVE The sheave at the center of a rope system over which no rope movement occurs other than equalizing movement. It can be a source of severe degradation and must be part of regular rope inspections .

EQUALIZING SLINGS Multiple-leg slings composed of wire rope and fittings that are designed to help distribute the load equally..

EQUALIZING THIMBLES Special type of load-distributing fitting used as a component of certain wire rope slings.

EXTRA EXTRA IMPROVED PLOW STEEL (EEIP) A grade of wire rope.

EXTRA IMPROVED PLOW STEEL ROPE (EIP) A grade of wire rope.

EYE OR EYE SPLICE A loop with or without a thimble, formed at the end of a wire rope.

FACTOR OF SAFETY In the wire rope industry, this term was originally used to express the ratio of nominal strength to the total working load. The term is no longer used since it implies a permanent existence for this ratio when, in actuality, the rope strength begins to reduce the moment it is placed in service. The term currently used is "design factor".

FATIGUE As applied to wire rope, the term usually refers to the process of progressive fracture resulting from the bending of individual wires. These fractures may and usually do occur at bending stresses well below the ultimate strength of the material; it is not an abnormality although it may be accelerated due to operating conditions such as high loads, small sheaves, rust or lack of lubrication.

FERRULE A metallic button, usually cylindrical in shape, normally fastened to a wire rope by swaging but sometimes by spelter socketing.

FIBER CENTER Cord or rope of natural or synthetic fiber used as the axial member of a strand.

FIBER CORE Cord or rope of natural or synthetic fiber used as the axial member of a rope.

FILLER WIRE Small spacer wires within a strand which help position and support other wires. Also the name for the type of strand pattern utilizing filler wires.

FITTING An accessory attached to a wire rope.

FLATTENED STRAND ROPE Wire rope that is made either of oval or triangular shaped strands in order to form a flattened rope surface.

FLEET ANGLE That angle between the rope's position at the extreme end wrap on a drum, and a line drawn perpendicular to the axis of the drum through the center of the nearest fixed sheave.

GALVANIZED Zinc coating used on wire for corrosion resistance.

GALVANIZED ROPE Wire rope made up of strands of galvanized wire.

GALVANIZED STRAND Strand made up of galvanized wire.

GRADE Wire rope or strand classification by strength and/or type of material, i.e., Improved Plow Steel, Type 302 Stainless, etc. It does not imply a strength of the basic wire used to meet the rope's nominal strength.

GRADES, ROPE Classification of wire rope by the wire's metallic composition and the rope's minimum breaking force.

GROMMET An endless circle or ring fabricated from one continuous length of strand or rope.

GROOVED DRUM Drum with a grooved surface that accommodates the rope and guides it for proper winding. The groove may be helical or parallel.

GUY LINE Strand or rope, usually galvanized, for stabilizing or maintaining a structure in fixed position.

HAULAGE ROPE Wire rope used for pulling movable devices such as cars that roll on a track.

HAWSER Wire rope, usually galvanized, used for towing or mooring marine vessels.

HOLDING LINE Wire rope on a clamshell or orange peel bucket that suspends the bucket while the closing line is released to dump its load.

IDLER Sheave or roller used to guide or support a rope.

IMPROVED PLOW STEEL ROPE (IPS) A grade of wire rope.

INCLINE ROPE Rope used in the operation of cars on an inclined haulage.

INDEPENDENT WIRE ROPE CORE (IWRC) A wire rope used as the axial member of a larger wire rope.

INNER WIRES All wires of a strand except the outer or cover wires.

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INTERNALLY LUBRICATED Wire rope or strand having all of its wire components coated with lubricants.

IRON ROPE A grade of wire rope.

KINK A unique deformation of a wire rope caused by a loop of rope being pulled down tight. It represents irreparable damage and an indeterminate loss of strength in the rope.

LAGGING a) External wood covering on a reel to protect the wire rope or strand, or b) the grooved shell of a drum.

LANG LAY ROPE See LAY , TYPES.

LAY a) The manner in which the wires in a strand or the strands in a rope are helically laid, or b) the distance measured parallel to the axis of the rope (or strand) in which a strand (or wire) makes one complete helical convolution about the core (or center). In this connection, lay is also referred to as LAY LENGTH or PITCH.

LAY, TYPES
1) *Right Lay:* The direction of strand or wire helix corresponding to that of a right hand screw thread.
2) *Left Lay*: The direction of strand or wire helix corresponding to that of a left hand screw thread.
3) *Cross Lay*: Rope or strand in which one or more operations are performed in opposite directions. A multiple operation product is described according to the direction of the outside layer.
4) *Regular Lay:* The type of rope wherein the lay of the wires in the strand is in the opposite direction to the lay of the strand in the rope. The crowns of the wires appear to be parallel to the axis of the rope.
5) *Lang Lay*: The type of rope in which the lay of the wires in the strand is in the same direction as the lay of the strand in the rope. The crowns of the wires appear to be at an angle to the axis of the rope.
6) *Alternate Lay*: Lay of a wire rope in which the strands are alternately regular and lang lay.
7) *Reverse Lay*: Another term for alternate lay.

LAY LENGTH See LAY (b).

LEAD LINE That part of a rope tackle leading from the first, or fast, sheave to the drum. See DRUM and SHEAVE.

LEFT LAY See LAY, TYPES.

LOCKED COIL STRAND Smooth-surfaced strand ordinarily constructed of shaped, outer wires arranged in concentric layers around a center of round wires.

MARLINE SPIKE Tapered steel pin used as a tool for splicing wire rope.

MARTENSITE A nonductile microstructure of steel formed when the steel is heated above its critical temperature and rapidly quenched. This occurs in wire rope as a result of frictional heating and the mass cooling effect of the cold metal beneath. Martensite cracks very easily, and such cracks can propagate from the surface through the entire wire.

MILKING The progressive movement of strands along the axis of the rope, resulting from the rope's movement through a restricted passage such as a tight sheave.

MODULUS OF ELASTICITY The slope of the secant to the stress-strain curve between 10% of the rope's minimum breaking force and 90% of the prestretching force.

MOORING LINES Galvanized wire rope used for holding ships to dock.

NON-PREFORMED Rope or strand that is not preformed.

OPEN SOCKET A wire rope fitting that consists of a *basket* and *two ears* with a pin. See FITTING.

OUTER WIRES Outer layer of wires in a strand.

PEENING Permanent distortion resulting from cold plastic metal deformation of the outer wires. Usually caused by pounding against a sheave or machine member, or by heavy operating pressure between rope and sheave, rope and drum, or rope and adjacent wrap of rope.

PITCH See LAY (b).

PREFORMED STRANDS Strand in which the wires are permanently formed during fabrication into the helical shape they will assume in the strand.

PREFORMED WIRE ROPE Wire rope in which the strands are permanently formed during fabrication into the helical shape they will assume in the wire rope.

PRESSED FITTINGS Fittings attached by means of cold forming on the wire rope.

PRESTRESSING An incorrect reference to PRESTRETCHING.

PRESTRETCHING Subjecting a wire rope or strand to tension prior to its intended application, for an extent and over a period of time sufficient to remove most of the CONSTRUCTIONAL STRETCH.

PROPORTIONAL LIMIT As used in the rope industry, this term has virtually the same meaning as ELASTIC LIMIT. It is the end of the load versus elongation relationship at which an increase in load no longer produces a proportional increase in elongation and from which point recovery to the rope's original length is unlikely.

RATED CAPACITY The load which a new wire rope or wire rope sling may handle under given operating conditions and at an assumed DESIGN FACTOR.

REEL A flanged spool on which wire rope or strand is wound for storage or shipment.

REEVE To pass a rope through a hole or around a system of sheaves.

REGULAR LAY ROPE See LAY, TYPES.

REVERSE BEND Reeving a wire rope over sheaves and drums so that it bends in opposing directions.

REVERSE LAY See LAY, TYPES.

RIGHT LAY See LAY, TYPES.

ROLLERS Relatively small-diameter cylinders, or wide-faced sheaves, that serve as support for ropes.

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ROTARY DRILL LINE On a rotary drilling rig, it is the wire rope used for raising and lowering the drill pipe, as well as for controlling its position.

ROTATION RESISTANT ROPE A wire rope consisting of an inner layer of strand laid in one direction covered by a layer of strand laid in the opposite direction. This has the effect of counteracting torque by reducing the tendency of finished rope to rotate.

ROUND WIRE TRACK STRAND Strand composed of concentric layers of round WIRES, used as TRACK CABLE, sometimes called SMOOTH-COIL TRACK STRAND.

SAFE WORKING LOAD This term is potentially misleading and is, therefore, in disfavor. Essentially, it refers to that portion of the rope's minimum breaking force that can be applied either to move or sustain a load. It is misleading because it is only valid when the rope is new and equipment is in good condition.

SAND LINE Generally a 6x7 wire rope that is used in well servicing.

SEALE The name for a type of strand pattern that has two adjacent layers laid in one operation with any number of uniform sized wires in the outer layer, and with the same number of uniform but smaller sized wires in the inner layer.

SEIZE To make a secure binding at the end of a wire rope or strand with SEIZING WIRE or SEIZING STRAND.

SEIZING STRAND Small diameter STRAND usually made up of 7 wires.

SEIZING WIRE A wire for seizing.

SERVE To cover the surface of a wire rope or strand with a fiber cord or wire wrapping.

SHACKLE A U- or anchor-shaped fitting with pin.

SHEAVE A grooved pulley for wire rope.

SLING, WIRE ROPE An assembly fabricated from wire rope which connects the load to the lifting device.

SLING, BRAIDED A flexible sling, the body of which is made up of two or more WIRE ROPES braided together.

SMOOTH-FACED DRUM Drum with a plain, ungrooved surface.

SOCKET Generic name for a type of wire rope fitting.

SPIRAL GROOVE A continuous helical groove that follows a path on and around a drum face, similar to a screw thread.

SPLICING 1) Making a loop or eye in the end of a rope by tucking the ends of the strands back into the main body of the rope. 2) Formation of loops or eyes in a rope by means of mechanical attachments pressed onto the rope. 3) Joining of two rope ends so as to form a long or short splice in two pieces of rope.

SPRING LAY See LAY, TYPES.

STAINLESS STEEL ROPE Wire rope made up of corrosion resistant steel wires.

STIRRUP The eyebolt attachment on a bridge socket.

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STRAND A plurality of round or shaped wires helically laid about an axis.

STRANDER A machine that lays wires together helically to form a strand.

STRETCH The elongation of a wire rope under load.

SWAGED FITTING Fitting into which wire rope can be inserted and then permanently attached by cold pressing (swaging) the shank that encloses the rope.

TAG LINE A small wire rope used to prevent rotation of a load.

TAPERING AND WELDING Reducing the diameter of a wire rope at its end, and then welding the wires so as to facilitate reeving.

THIMBLE Grooved metal fitting to protect the eye, or fastening loop of a wire rope.

TRACK CABLE On an aerial conveyor it is the suspended wire rope or strand along which the carriers move.

TRACTION ROPE On an aerial conveyor or haulage system it is the wire rope that propels the carriages.

TRACTION STEEL ROPE A specific grade of wire rope.

TRAMWAY An aerial conveying system for transporting multiple loads.

WARRINGTON The name for a type of strand pattern that is characterized by having one of its wire layers (usually the outer) made up of an arrangement of alternately large and small wires.

WEDGE SOCKET Wire rope fittings in which the rope end is secured by a wedge.

WHIPPING A synonymous term for SEIZING. Also, it has been suggested as punishment for those who neglect the cautionary rules in this publication.

WIRE (ROUND) A single, continuous length of metal, with a circular cross section that is cold-drawn from rod.

WIRE (SHAPED) A single, continuous length of metal with a non circular cross section that is either cold-drawn or cold-rolled from rod.

WIRE ROPE A plurality of wire strands helically laid about an axis.

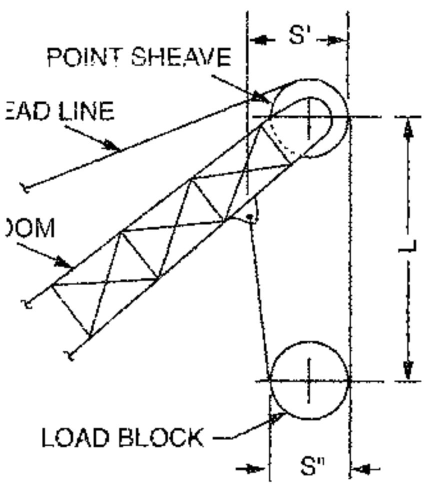
WIRE STRAND CORE (WSC) A wire strand used as the axial member of a wire rope.

Appendix E

BLOCK SPINNING (CABLING)

Since the invention of the crane, one problem has been prevalent during many lifting operations—spinning of the load or rotation of the traveling blocks. While spinning of the load can occur at any fall length, block rotation usually does not pose a problem until a certain height is reached. In either case, lifting can be severely limited or halted due to these conditions.

The formula, shown below, predicts the length at which "cabling" of multiple-part reevings will occur. This formula incorporates the variables of rope spacing at both the point and traveling block sheaves; the torque provided by the rope; length of fall; and the number of parts of line.



$$L = \frac{S' \times S'' \times \sin\theta}{K \times Tf}$$

L = Fall Length—Feet
S' = Rope Spacing at Boom Point—Inches
S" = Rope Spacing at Traveling Block Sheaves—Inches
K = Variable for Number of Parts of Line
Tf = Torque Factor of Rope—Inch Pound Per Pound
θ = Angle of Block Rotation-Degrees

The definition of cabling is that point at which the blocks spin to entangle the hoist line. This point has been defined to be when the traveling block has turned 90 degrees from its neutral position. The equation can therefore be reduced to the following to indicate at what point cabling is likely to occur.

$$L = \frac{S' \times S''}{K \times Tf} = \text{Sin 90 Degrees} = \frac{S' \times S''}{K \times Tf}$$

VALUES OF CONSTANT K	
No. of Wire Rope Parts	K
2	48
3	72
4	42
5	63
6	36
7	54

It should be noted that this formula neglects the effects of load, but is only correct above a certain minimum load. This load is that force required to overcome the internal frictional force of the rope and inertia of the traveling block. That is, this formula is invalid until the rope has been loaded to the point that allows the external rope strands to act independently of the internal core strands, thus producing sufficient torque to rotate the blocks. Once this minimum load has been reached, loads above this value have no effect on block rotation. This formula then becomes valid and approximates the fall length at which cabling occurs. This minimum load is approximately 10% of the nominal rope strength, or any design factor greater than 10 to 1.

The torque values of rope constructions vary mostly because of the physical characteristics of the design. That is, 6 x 25 Filler Wire, Independent Wire Rope Core rope is designed so that the outer rope strands and the strands of the core are laid in the same direction. Thus, whenever a load is applied, both the rope and the core have a tendency to unlay in the same direction. Conversely, when a Rotation-resistant rope is tensioned, the unlaying effect of the outer rope strands is greatly reduced due to the fact that the strands of the core are laid in opposite direction to the outer rope strands. But even rotation resistant ropes twist due to the greater torque applied by the outer strands over the core strands.

With rotation resistant ropes, the torque factors vary according to the number and lay length of outer strands, the construction and lay length of the core and the lay type (Regular or Lang) of the rope and core.

Bands are used to cover the rotational properties of the various ropes. The bands on the graph in figure E1 display the approximate limitations of the four rope types in a multi-part system. Four independent variables are used as parameters and are used in pairs to locate a reference point on the graph. They are grouped as follows:

L/S= Length of fall per unit rope spacing

D/d= Average pitch diameter of block and crown sheaves per unit rope diameter.

(For 2-fall system, with parallel falls, the ratio is the pitch diameter of the sheave divided by the nominal rope diameter.)

Various constructions of rope shown in the graph indicate the limited conditions for torsional stability with the angular displacement of the hoist block to maximum of 90 degrees. When the operating conditions for a particular installation lie above the appropriate wire rope construction band, then cabling of the falls most likely will occur. If the operating conditions lie below any particular band, then cabling of the falls will most likely not occur. If the operating conditions for any particular installation fall within the band, cabling is unpredictable.

EXAMPLE

A 2-fall crane uses 3/4" diameter hoist rope and a block with a pitch diameter of 18 inches. The rope spacing is assumed to be parallel and the height of lift required is 100 feet. Based upon these conditions we would have the following values:

d=.75 inches
D=18 inches
S=1.5 feet
L=100 feet

L/S=66.7
D/d=24

Using these numbers and entering the graph, we find that it would be a borderline condition for six-stranded, regular lay rope; however, there should be no trouble using one of the Rotation Resistant ropes.

"L" is the length of fall (feet) and is measured from the centerline of point sheave to the centerline of the sheave in the traveling block. "S" is the spacing of the outer ropes on even-part systems (2, 4, 6, 8 . . .). In odd-part systems (3, 5, 7, 9 . . .), the measurement of "S" is reduced by a factor below the next lowest even-part system as shown in Table E5. "D" is the average pitch diameter (inches) of the point and block sheaves, and "d" is the nominal wire rope diameter (inches).

TABLE E5
COMPUTING "S"

2-Part System=Average Pitch Diameter of Point and Block Sheave
3-Part System=2/3 of 2-Part System
4-Part System=Diagonal Distance of Rope Parts
5-Part System=4/5 of 4-Part System.
6-Part System-Diagonal Distance of Rope Parts
7-Part System-6/7 of 6-Part System

In summary, the four variables, which can be established for a given condition, are to he used to calculate the probability of cabling. It must be remembered that this concept is based upon proper handling and reeving of the wire rope on the machine. Any undue twist which is in the rope during operation will affect the torsional properties of the line. Suggestions as to proper handling of the rope in the field can be obtained from any wire rope producer. It should also be noted that differences in rope manufacturing may be sufficient to yield variations in the results. All lifts where cabling may occur should be approached with caution.

Appendix E

WIRE ROPE CABLING BANDS

SYSTEM STABLE BELOW, UNSTABLE ABOVE, UNCERTAIN WITHIN BAND

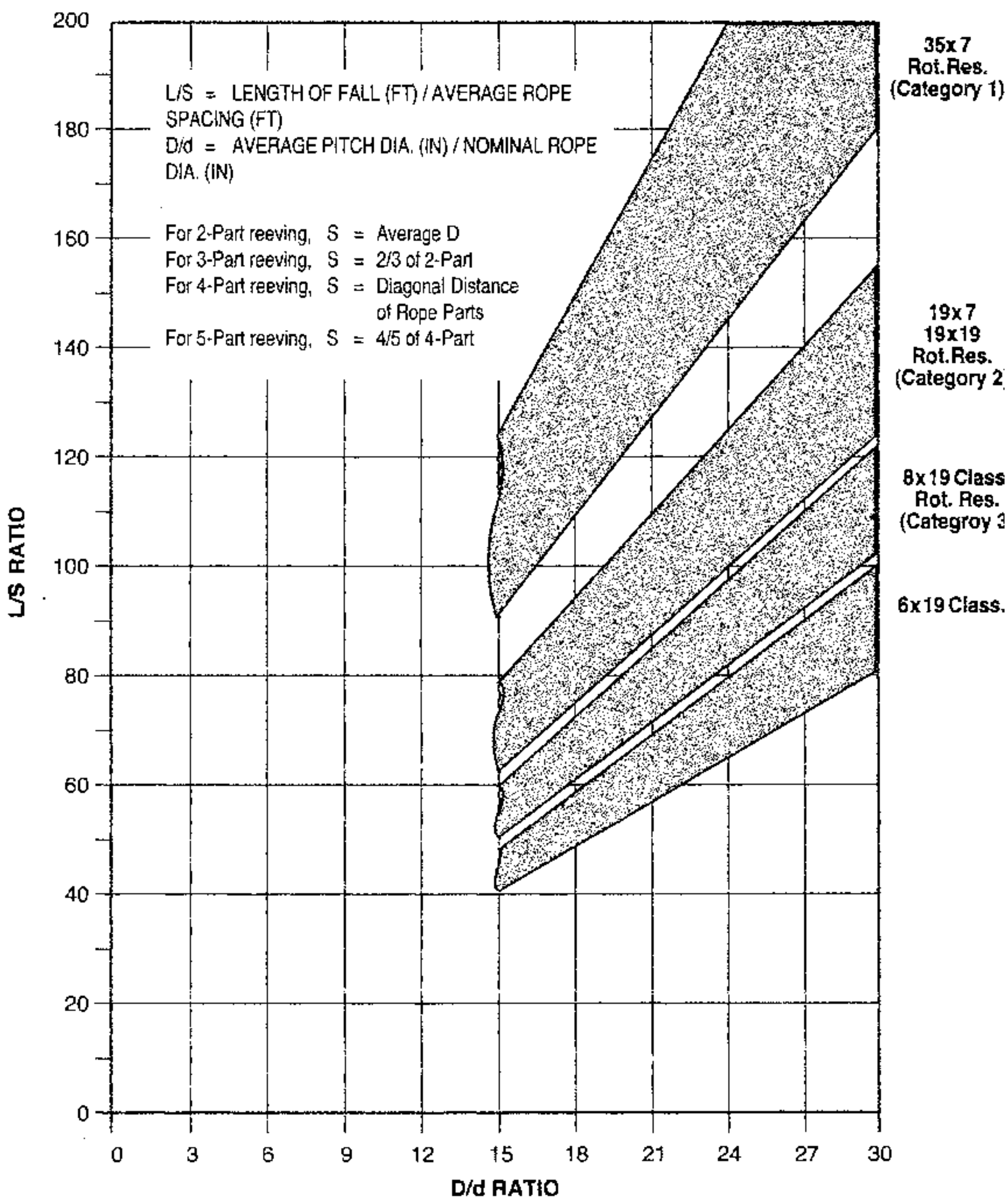


Figure E1

Appendix E

The following steps tend to reduce cabling:

- Reduce wire rope length. Longer wire rope lengths cause more rotation, due to unlaying, than shorter wire rope lengths.

- Replace fiber core wire rope with an IWRC wire rope. Fiber core wire ropes have a higher torque factor than IWRC wire ropes.

- Eliminate odd-part reeving. Even number of parts is more stable than odd.

- In installations where the wire rope dead end is on the load block, re-reeve to the next higher number of parts, and dead end the wire rope on the fixed block.

- While maintaining the same design factor, use a smaller size wire rope.

- Increase the spread between the wire rope falls. Use either larger sheaves, or dead end the wire rope away from the wire rope falls (check the integrity of the structure).

- Restrain the load block with a tag line.

Appendix F INTERNATIONAL STANDARD ROPE DESIGNATIONS

COMPONENT	INTERNATIONAL SYMBOL	U.S. SYMBOL
STRAND:		
Triangular (Flattened)	V	Flattened
Oval	Q	Oval
Compacted	K	Compacted
Flat or Ribbon	P	Ribbon
Compacted Rope	K	Swaged
STRAND CONSTRUCTION:		
Seale	S	S
Warrington	W	W
Filler Wire	F	FW
(Example Compound Construction)		
Warrington Seale	WS	WS
Seale Warrington Seale	SWS	SWS
Filler Seale	FS	FWS
ROPE CORE:		
Fiber Core	CF	FC
Natural Fiber	CFN	HFC or VFC
Synthetic Fiber	CFS	PFC or PPC
Independent Wire Rope	CWR	IWRC
Plastic Coated	CWREC	
Plastic Filled	CWREF	
WIRE FINISH:		
Bright (Carbon Steel)	B	Bright
Zinc Coated	G	Galvanized
LAY TYPE AND DIRECTION:		
Right Lay	Z	RL
Left Lay	S	LL
Left Regular	zS	LRL
Left Lang	sS	LLL
Right Regular	sZ	RRL
Right Lang	zZ	RLL
Alternate	A	ALTERNATE LAY
PREFORMATION:		
Preformed	PRE	Preformed
Non-Preformed	NON-PRE	Non-Preformed

Reference ISO 3508

Appendix G UNIT CONVERSION FACTORS

FROM ——— MULTIPLY BY ——→		TO
TO ←———	DIVIDE BY———	FROM
inches	25.40	millimeters
feet	.3048	meters
yards	.9144	meters
acres	43,560	square feet
atmospheres	76	cm of mercury
atmospheres	29.92	in. of mercury
atmospheres	10,332	kg/sq. meter
atmospheres	14.70	lbs./sq. in.
BTU	777.97	foot-lbs.
calories (large)	426.85	kilogram-meters
circular mils	.7854	square mils
celcius	(C° x 9/5) + 32	fahrenheit
miles(statute)	1.609	kilometers
cubic inches	16.39	cubic centimeters
cubic inches	5.787×10^{-4}	cubic feet
cubic inches	1.639×10^{-5}	cubic meters
cubic inches	2.143×10^{-5}	cubic yards
cubic inches	4.329×10^{-3}	gallons
dynes	7.233×10^{-5}	poundals
ergs	$.9475 \times 10^{-10}$	btu
ergs	7.3756×10^{-3}	foot-lbs
ergs	$.2390 \times 10^{-7}$	gram calorie
ergs	$.2778 \times 10^{-10}$	watthour
cubic feet	.02832	cubic meters
cubic yards	.7646	cubic meters
grams	980.665	dynes
grams	15.432	grains
grams	.07093	poundals
grams	2.205×10^{-3}	pounds
grams/cm	5.600×10^{-3}	lbs/in
grams/cu cm	.03613	lbs/cu in
grams/sq cm	2.0481	lbs/sq ft
grams/sq m	.00328	ozs/sq ft
horsepower	42.40	btu/min
horsepower	33,000	ft-lbs/min
horsepower	10.68	kg calories/min
inches	2.540	centimeters
inches	8.333×10^{-2}	feet
inches	1.578×10^{-5}	miles
inches	2.778×10^{-2}	yards
kilometers	.62137	miles
kilowatt-hrs	3413	btu
kilowatt-hrs	2.656×10^{6}	ft-lbs
kilowatt-hrs	1.341	horsepower-hrs

Appendix G UNIT CONVERSION FACTORS

FROM ———— MULTIPLY BY ———→ TO

TO ←———— DIVIDE BY ———— FROM

kilowatt-hrs	3.6×10^6	joules
kilowatt-hrs	860	kilogram-calories
kilowatt-hrs	3.672×10^5	kilogram-meters
kilograms force	2.2046	pounds force
kilograms force	9.8066	Newtons/sq mm
kilograms/m	.6720	lbs/ft
kilograms/sq mm	1422.33	lb force/sq in
kilonewton	224.8	lb force
liters	10^3	cubic cm
liters	61.02	cubic inches
liters	10^{-3}	cubic meters
liters	1.308×10^{-3}	cubic yards
liters	2.1134	points (liquid)
meters	39.37	inches
meters	6.214×10^{-4}	miles
meters	1.094	yards
meters/min	1.667	cm/sec
meters/min	0.06	kilometers/hr
meters/min	.03728	miles/hr
miles (nautical)	6080.2	feet
miles (nautical)	.1516	miles (statute)
miles (statute)	5280	feet
miles (statute)	1760	yards
miles/hr	88	ft/min
miles/hr	1.467	ft/sec
miles/hr	0.8684	knots
Newton/sq mm	.102	kg force/sq mm
ozs/sq ft	304.88	grams/sq m
poundals	0.03108	pounds (wt)
pound force	4.448	newton
pound force	.004448	kilonewton
pound force	.4536	kilogram force
pound force/sq in	7.030×10^{-4}	kg force/sq mm
pound/ft	1.4881	kg/m
short tons	8.8970	kilonewton (KN)
short tons	.9072	metric tons
long tons	9.964	kilonewton (KN)
long tons	1.016	metric tons
pounds/foot	14.59	newton/meter
pounds/foot	1.488	kilograms/meter
pounds/sq. inch	.0007031	kilograms/sq. mm
pounds/sq. inch	.006895	newtons/sq. mm
short tons/sq. inch	1.406	kilograms/ sq mm

Appendix H UNIT CONVERSION FACTORS

FROM ———	MULTIPLY BY ——→	TO
TO ←———	DIVIDE BY ———	FROM
sq in	1.273×10^6	circular mils
sq in	6.452	sq cm
sq in	6.944×10^{-4}	sq ft
sq in	10^8	sq mils
sq in	7.716×10^{-4}	sq yards
sq meters	10.7639	sq ft
sq miles	2.590	sq km
short tons/sq. inch	13.79	newtons/sq. mm
tonnes	1.1023	tons (2000 lbs.)
long tons/sq. inch	1.575	kilograms/sq. mm
long tons/sq. inch	15.44	newtons/sq. mm
pounds/cu. ft.	16.02	kilograms/cu. meter
pounds/cu. ft.	157.1	newtons/cu. meter
imperial gallons	4.546	liters
US gallons	3.785	liters
watts	.05688	btu/min
watts	10^7	ergs/sec
watts	44.27	ft-lbs/min

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Warning Label Program for Wire Rope Industry

This program makes available for purchase a method to advise users and operators of wire rope systems and assemblies that there exist potential dangers in the use of wire rope.

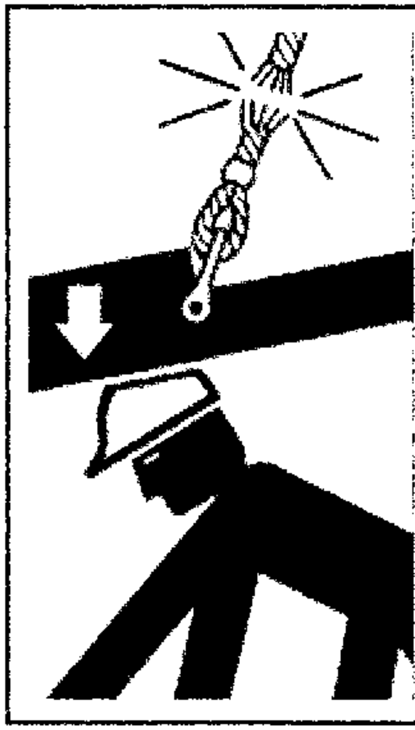
The program includes a Warning Label (or tag) for affixing to shipping reels and coils, to fabricated wire ropes such as slings, and to equipment on which wire rope is installed.

Also offered for purchase is a 4-page brochure. "**WIRE ROPE AND WIRE ROPE SLING SAFETY BULLETIN**", which outlines some of the hazards in the use of wire rope, and precautions which must be taken by the user to help avoid injury.

Three types of the Warning Label are available: (1) A flat label, 4" x 6 1/2", printed with a weather-durable ink on TYVEK plastic impregnated paper stock that may be glued or stapled to wood reels; (2) An identical label on TYVEK with metal eyelet that may be attached to coils of wire rope and wire rope slings; (3) An identical label printed on white MYLAR, with contact adhesive backing, for affixing to metal reels, wire rope-using equipment and to smooth, hard surfaces.

These materials are being offered at the cost of developing and printing, plus a shipping and handling charge. Distribution is by a private order fulfillment contractor.

Contact the WRTB fulfillment center at 1-888-289-9782, or Fax 1-816-232-8538 for ordering information.



WARNING

Wire Rope WILL FAIL if worn-out, overloaded, misused, damaged, improperly maintained or abused.

Wire rope failure may cause serious injury or death!

Protect yourself and others:

- **ALWAYS INSPECT wire rope for WEAR, DAMAGE or ABUSE BEFORE USE.**
- **NEVER USE wire rope that is WORN-OUT, DAMAGED or ABUSED.**
- **NEVER OVERLOAD a wire rope.**
- **INFORM YOURSELF: Read and understand manufacturer's literature or "Wire Rope and Wire Rope Sling Safety Bulletin".***
- **REFER TO APPLICABLE CODES, STANDARDS and REGULATIONS for INSPECTION REQUIREMENTS and REMOVAL CRITERIA.***

*** For additional information or the BULLETIN, ask your employer or wire rope supplier.**

 Form No. 193

WIRE ROPE AND WIRE ROPE SLING SAFETY BULLETIN

The following four pages are a reprint of the 4-page brochure published by WRTB for use in conjunction with a Warning Label Program developed for the wire rope industry

Wire Rope Technical Board

Some Things Every User Should Know About Use and Care of

The following information is NOT a complete discussion of wire rope or wire rope slings.
WHAT FOLLOWS IS A BRIEF OUTLINE OF THE BASIC INFORMATION REQUIRED TO SAFELY USE WIRE ROPE AND WIRE ROPE SLINGS.

---

1. Wire rope WILL FAIL IF WORN OUT, OVERLOADED, MISUSED, DAMAGED or IMPROPERLY MAINTAINED.

2. In service, wire rope loses strength and work capability. Abuse and misuse increase the rate of loss.

3. The NOMINAL STRENGTH, sometimes called CATALOG strength, of a wire rope applies ONLY to a NEW, UNUSED rope.

4. The Nominal Strength of a wire rope SHOULD BE CONSIDERED the straight line pull which will ACTUALLY BREAK a new, UNUSED rope. The Nominal Strength of a wire rope should NEVER BE USED AS ITS WORKING LOAD.

5. To determine the working load of a wire rope, the NOMINAL strength MUST BE REDUCED by a DESIGN FACTOR (formerly called a Safety Factor). The Design Factor will vary depending upon the type of machine and installation, and the work performed. YOU must determine the applicable Design Factor for your use.

   For example, a Design Factor of "5" means that the Nominal Strength of the wire rope must be DIVIDED BY FIVE to determine the maximum load that can be applied to the rope system.

   Design Factors have been established by OSHA, by ANSI, by ASME and similar government and industrial organizations.

   No wire rope or wire rope sling should ever be installed or used without full knowledge and consideration of the Design Factor for the application.

6. WIRE ROPES WEAR OUT. The strength of a wire rope begins to decrease when the rope is put in use, and continues to decrease with each use.

7. NEVER OVERLOAD A WIRE ROPE. This means NEVER USE the rope where the load applied to it is greater than the working load determined by dividing the Nominal Strength of the rope by the appropriate Design Factor.

8. NEVER "SHOCK LOAD" a wire rope. A sudden application of force or load can cause both visible external damage and internal damage. There is no practical way to estimate the force applied by shock loading a rope. The sudden release of a load can also damage a wire rope.

9. Lubricant is applied to the wires and strands of a wire rope when it is manufactured. This lubricant is depleted when the rope is in service and should be replaced periodically.

10. Regular, periodic INSPECTIONS of the wire rope, and keeping of PERMANENT RECORDS SIGNED BY A QUALIFIED PERSON, are REQUIRED BY OSHA FOR ALMOST EVERY WIRE ROPE INSTALLATION. The purpose of inspection is to determine whether or not a wire rope or wire rope sling may continue to be safely used on that application. Inspection criteria, including number and location of broken wires, wear and elongation, have been established by OSHA, ANSI, ASME and similar organizations.

    IF IN DOUBT, REPLACE THE ROPE.

    An inspection should include verification that none of the specified removal criteria for this usage are met by checking for such things as:

    - Surface wear: Normal and unusual.
    - Broken wires: Number and location.
    - Reduction in diameter.
    - Rope stretch (elongation).
    - Integrity of end attachments.

In addition, an inspection should include the condition of sheaves, drums and other apparatus with which the rope makes contact.

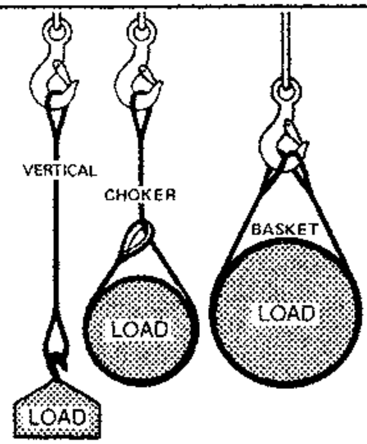
11. When a wire rope has been removed from service because it is no longer suitable for use, IT MUST NOT BE RE-USED ON ANOTHER APPLICATION.

12. Every wire rope user should be aware of the fact that each type of fitting attached to a wire rope has a specific efficiency rating which can reduce the working load of the rope assembly or rope system, and this must be given due consideration is determining the capacity of a wire rope system.

13. Some conditions that can lead to problems in a wire rope system include:

    - Sheaves that are too small, worn or corrugated cause damage to a wire rope.
    - Broken wires mean a loss of strength.
    - Kinks permanently damage a wire rope and must be avoided.
    - Wire ropes are damaged by knots, and wire ropes with knots must never be used.
    - Environmental factors such as corrosive conditions and heat can damage a wire rope.
    - Lack of lubrication can significantly shorten the useful service life of a wire rope.
    - Contact with electrical wires and the resulting arcing will damage a wire rope.

Wire Rope and Wire Rope Slings



Every Lift Uses 1 of 3 Basic Hitches

VERTICAL, or straight, attachment is simply using a sling to connect a lifting hook or other device to a load. Full rated load of the sling may be used, but never exceeded. A tagline should be used on such a lift to prevent rotation which can damage thesling. A sling with a hand-tucked splice can unlay and fail if the sling is allowed to rotate.

CHOKER hitches reduce lifting capability of a sling, since this method of rigging affects the ability of the wire rope components to adjust during the lift, places angular loading on the body of the sling, and creates a small diameter bend in the sling body at the choke point.

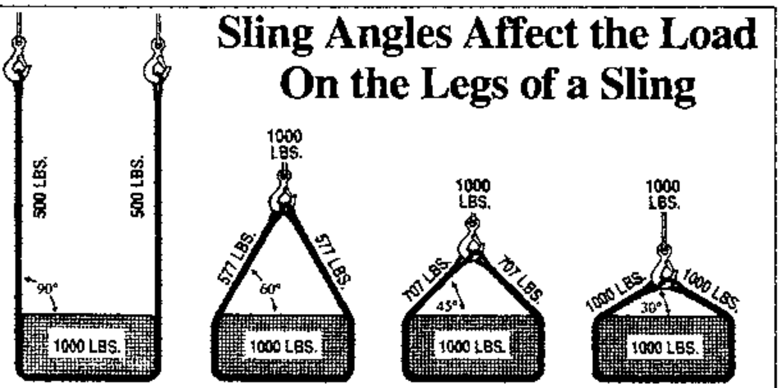
BASKET hitches distribute a load equally between the two legs of a sling, within limitations imposed by the angles at which legs are rigged to the load. (See discussion of sling angles below.)

Basic Factors Concerning Use of Wire Rope Slings

1. RATED LOAD (Rated Capacity) of a wire rope sling is based upon the Nominal, or Catalog, Strength of the wire rope used in the sling, AND FACTORS which affect the overall strength of the sling. These factors include ATTACHMENT or SPLICING EFFICIENCY, the number of parts of rope in the sling, type of hitch (e.g., straight pull, choker hitch, basket hitch), DIAMETER AROUND WHICH THE BODY OF THE SLING IS BENT, and the diameter of pin (or hook) over which the eye of the sling is rigged.
2. RATED LOAD of a sling is different for each of the three basic methods of rigging (See graphic above.). These rated loads are available from your wire rope sling supplier and may be indicated on the tag attached to the sling at the time it is fabricated (if requested by the user).
3. WARNING: A hand-tucked eye splice can unlay (unravel) and fail if the sling is allowed to rotate during use.
4. NEVER "SHOCK LOAD" A SLING. There is no practical way to estimate the actual force applied by shock loading. The rated load of a wire rope sling can easily be exceeded by a sudden application of force, and damage can occur to the sling. The sudden release of a load can also damage a sling.
5. The BODY of a wire rope sling should be PROTECTED with corner protectors, blocking or padding against damage by sharp edges or corners of a load being lifted. Sharp bends that distort the sling body damage the wire rope and reduce its strength.
6. ANY ANGLE other than vertical at which a sling is rigged increases the loading on the sling.
7. A sling should be given a VISUAL INSPECTION BEFORE EACH LIFT OR USAGE to determine if it is capable of safely making the intended lift.

   An inspection should include looking for such things as:
   - Broken wires.
   - Kinks or distortions of the sling body.
   - Condition of eyes and splices, and any attached hardware.
   - Reduction in diameter of the rope.
   - Any damage.
   - Corrosion.
8. Whenever a sling is found to be deficient, the eyes must be cut, or other end attachments or fittings removed to prevent further use, and the sling body discarded.
9. A SLING EYE should never be used over a hook or pin with a body diameter larger than the natural width of the eye. NEVER FORCE AN EYE ONTO A HOOK. The eye should always be used on a hook or pin with AT LEAST THE DIAMETER OF THE ROPE.

Sling Angles Affect the Load On the Legs of a Sling



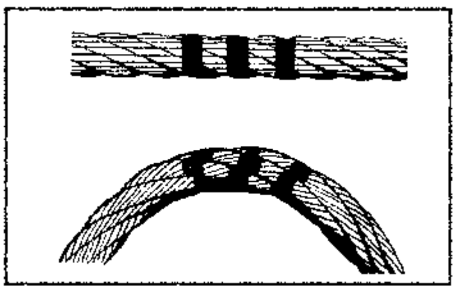
SLING ANGLE (also called Angle of Loading) is the angle measured between a horizontal line and the sling leg or body. This angle is very important and can have a dramatic effect on the rated load of the sling. As illustrated here, when this angle DECREASES, the LOAD ON EACH LEG INCREASES. This principle applies whether one sling is used with legs at an angle in a basket hitch, or for multi-leg bridle slings. Horizontal sling angles of LESS THAN 30 DEGREES SHALL NOT BE USED

A Wire Rope Is a "Machine" With Many Moving Parts

A wire rope is a machine, by dictionary definition: "An assemblage of parts...that transmit forces, motion, and energy one to another in some predetermined manner and to some desired end."

A typical wire rope may contain dozens – even hundreds – of individual wires which are formed and fabricated to operate at close bearing tolerances one to another. When a wire rope bends, each of its many wires slides and adjusts in the bend to accommodate the difference in length between the inside and the outside of the bend. The sharper the bend, the greater the movement.

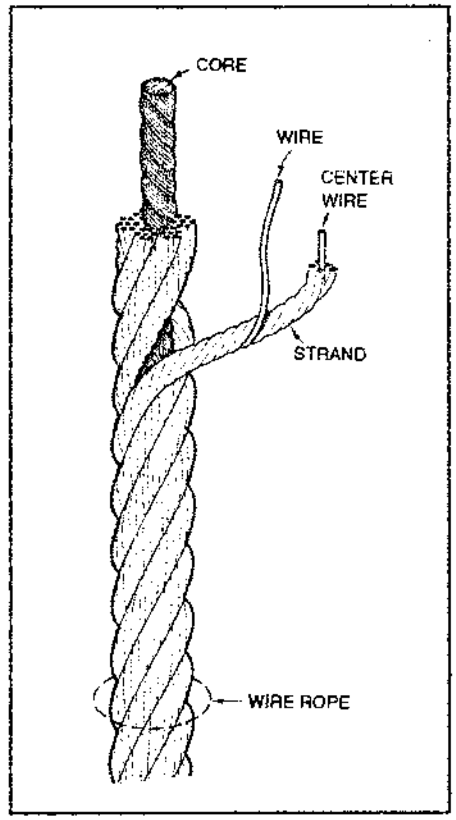
Every wire rope has three basic components: (1) The wires which form the strands and collectively provide rope strength; (2) The strands, which are laid helically around the core; and, (3) The core, which forms a foundation for the strands. The core may be either a fiber rope, an Independent Wire Rope Core (IWRC), which is actually a smaller wire rope, or a strand similar to the outer strands of the rope; only an IWRC or strand core contributes strength to the rope; and an IWRC normally provides only 7 1/2% of the wire rope's Nominal Strength.



The greatest differences in wire ropes are found in the strands, which may vary widely in the pattern and number of wires which are laid together.

The wires of a rope may be made of various metals, including steel, iron, stainless steel, monel, and bronze. The material of which the wires are made is the primary determinant of rope strength. By far the most widely used metal is high-carbon steel.

Carbon steel wire ropes come in various Grades. The term "Grade" is used to designate the Nominal Strength of the wire rope. The most common rope Grades are Traction Steel (TS), Plow Steel (PS), Improved Plow Steel (IPS), Extra Improved Plow Steel (EIPS), and Extra Extra Improved Plow Steel (EEIPS).



One cannot determine the Grade of a wire rope by its feel or appearance. To properly evaluate a rope system you must obtain the Grade from your employer or wire rope supplier.

This publication was produced by the Wire Rope Technical Board,
the technical information organization of the United States wire rope industry.
For further information, contact: wrtb@usa.net

Form 293

Printed in U.S.A

NOTES

Wire Rope Inspection Form

Date____________________ Inspector's Signature____________________

Description of this installation/usage____________________

Rope Description____________________ Date Installed ____________________

Manufacturer's Identification / Reel No ____________________

Location on Rope	Measured Diameter	No. of Broken Wires in 1 Rope Lay	in 1 strand of 1 Lay	Measured Lay Length	Comments

End Attachment No. 1: Condition and Comment ____________________

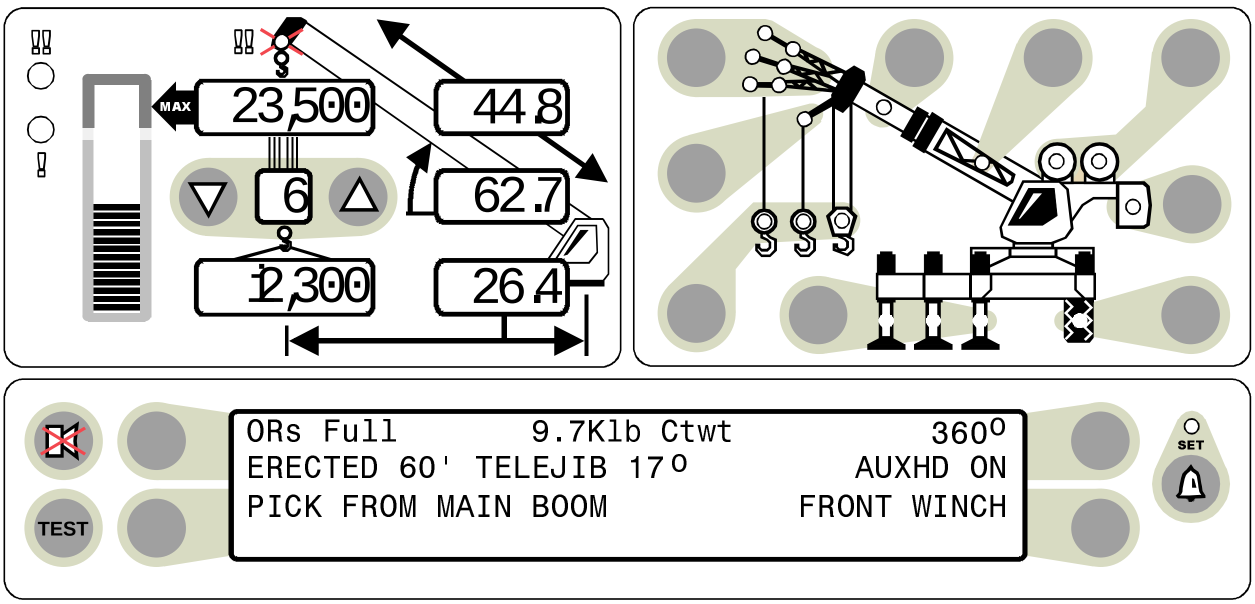
End Attachment No. 2: Condition and Comment ____________________

Drum Condition and Comment ____________________

Sheaves Condition and Comment ____________________

MICROGUARD®
TEREX RCI 510

TELESCOPIC BOOM CRANES



OPERATOR'S MANUAL

TABLE OF CONTENTS

OUTLINE OF OPERATION

SYSTEM COMPONENTS

- MicroGuard® Display Unit
- MicroGuard® Computer Unit
- Pressure Transducers
- Extension Reel with length and angle sensors
- Anti 2-Block (ATB) switches
- Cables
- Installation/Operator Manuals

The MicroGuard® TEREX RCI 510 System is intended to aid the crane operator by continuously monitoring the load and warning of an approach to an overload or Two-Block condition. Crane functions are monitored by means of high accuracy sensors. The system continuously compares the load suspended below the boom head with the crane capacity chart stored in the computer memory. At approach to overload, the system warns by means of audible and visual alarms. The system can be configured to cause function kick-out by sending a signal to function disconnect solenoids.

DISPLAY

The operator is provided with a continuous display of:

- Rated Load
- Actual Load
- Bar Graph showing Percentage of Rated Load
- Radius of the Load
- Boom Angle
- Main Boom Length
- Working Area
- Crane Configuration

On-screen messages provide the operator with visual warnings of conditions that occur during operation of the system.

BOOM ANGLE SENSOR

Boom angle is measured by means of a high-accuracy potentiometer/pendulum assembly that is damped to prevent overswing. It provides a voltage proportional to boom angle. The boom angle sensor is mounted inside the cable extension reel assembly.

EXTENSION SENSOR

The extension sensor provides an increasing voltage proportional to the extension of the boom. A cable attached to the boom head provides a low current electrical path for the A2B signal

PRESSURE TRANSDUCERS

Two pressure transducers measure the pressure in the boom hoist cylinder. The resultant Total Moment signal is processed to provide a continuous display of the load suspended below the point of lift.

ANTI TWO BLOCK (A2B)

A switch monitors the approach of the hookblock or overhaul ball to the boom head. The switch is held in the normal position until the hookblock or overhaul ball raises a weight that is mounted around the hoist rope. When the weight is raised, it causes the switch to operate. The resultant signal is sent to the computer via the extension reel causing the A2B alarm to operate and function kick-out to occur.

FUNCTION KICK-OUT

Electrically operated solenoids disconnect the control lever functions for boom hoist lower, telescope out, and winch up whenever an overload or an A2B condition occurs.

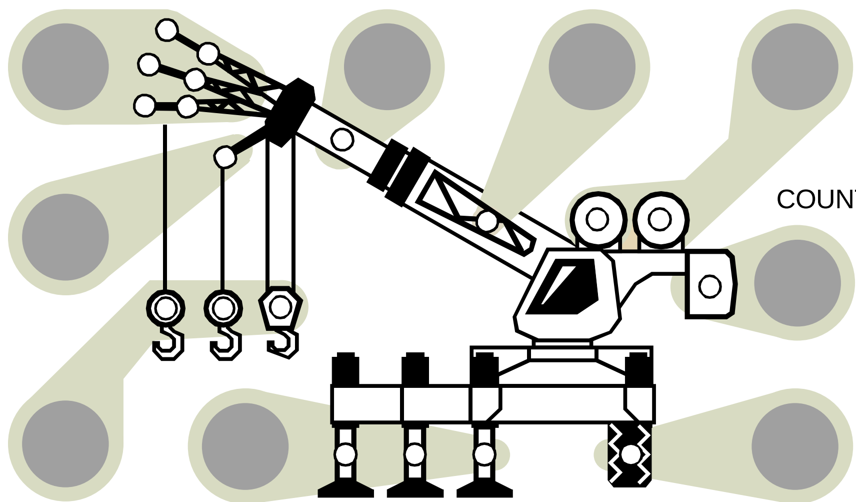
OPERATOR SETTABLE ALARMS

These alarms, when properly set by the operator, define the operating range. This is achieved by means of minimum and maximum angle, maximum height, and/or maximum length. These alarms can be programmed for each job site and allow the operator to work in a defined area.

AREA ALARM

When set, this alarm permits the operator to define the operating zone by only two set points. The use of this method of setting results in a greatly enhanced working area, and also clearly defines the operating zone.

THE PICTOGRAPH



The **PICTOGRAPH** gives a pictorial representation of the current setup of the system. It does this by means of light emitting diodes (LEDs). Each shaded area contains a group of one or more LEDs and a push button that is pressed to change the setup selection. In the groups with more than one choice or option, LED's illuminate one at a time to indicate the selection. The groups are shown below.

OUTRIGGERS - contain 3 LEDs. These indicate the selection of either full outriggers, intermediate, or retracted outriggers.

TIRES - contain 1 LED. When operation on tires is selected, the outrigger LED will turn off and the tire LED will illuminate.

COUNTERWEIGHT - contains 1 LED. It is only active on cranes that have counterweight options.

WINCH - contains 2 LEDs. These indicate the selection of FRONT or REAR winch.

STOWED JIB - contains 1 LED. This will be illuminated when the jib is stowed on the boom.

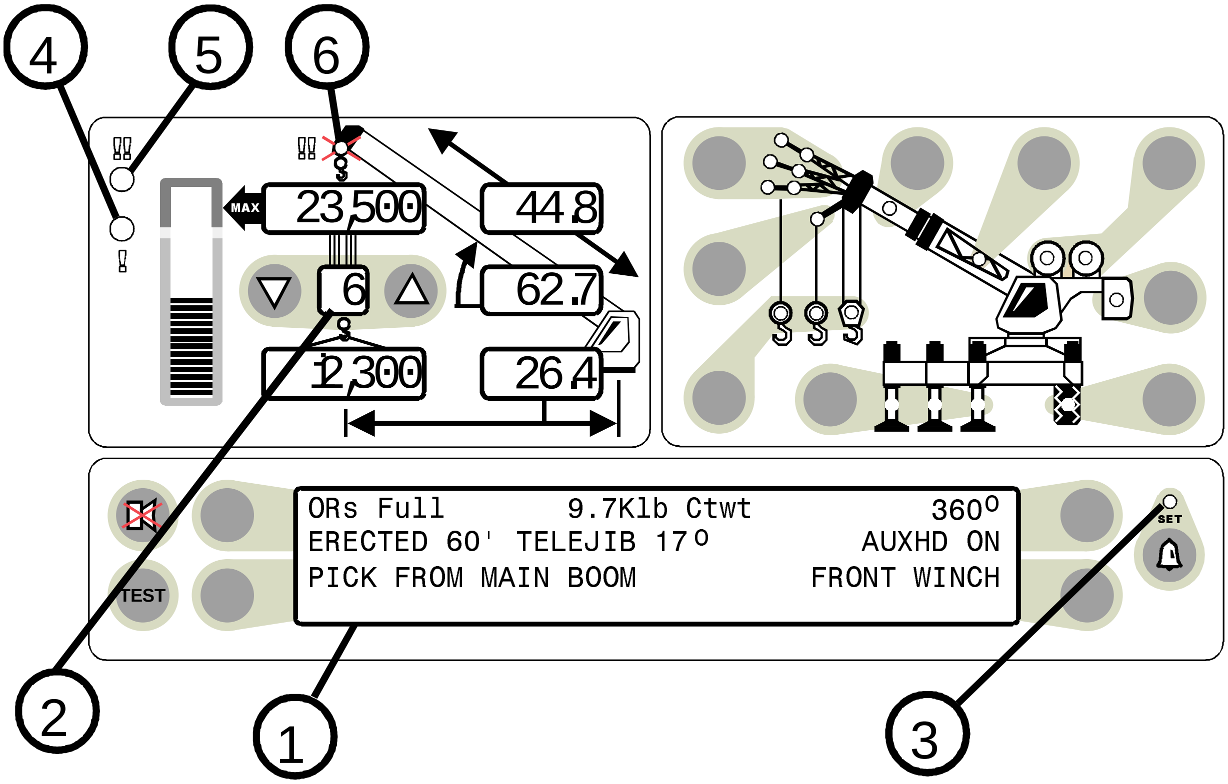
MANUAL SECTION - contains 1 LED. It is active on cranes that have pinned extensions or active tip boom options.

JIBS - contain 6 LEDs. These indicate the length and offset of the jib in use.

AUX HEAD - contains 1 LED that illuminates when the AUX HEAD is fitted.

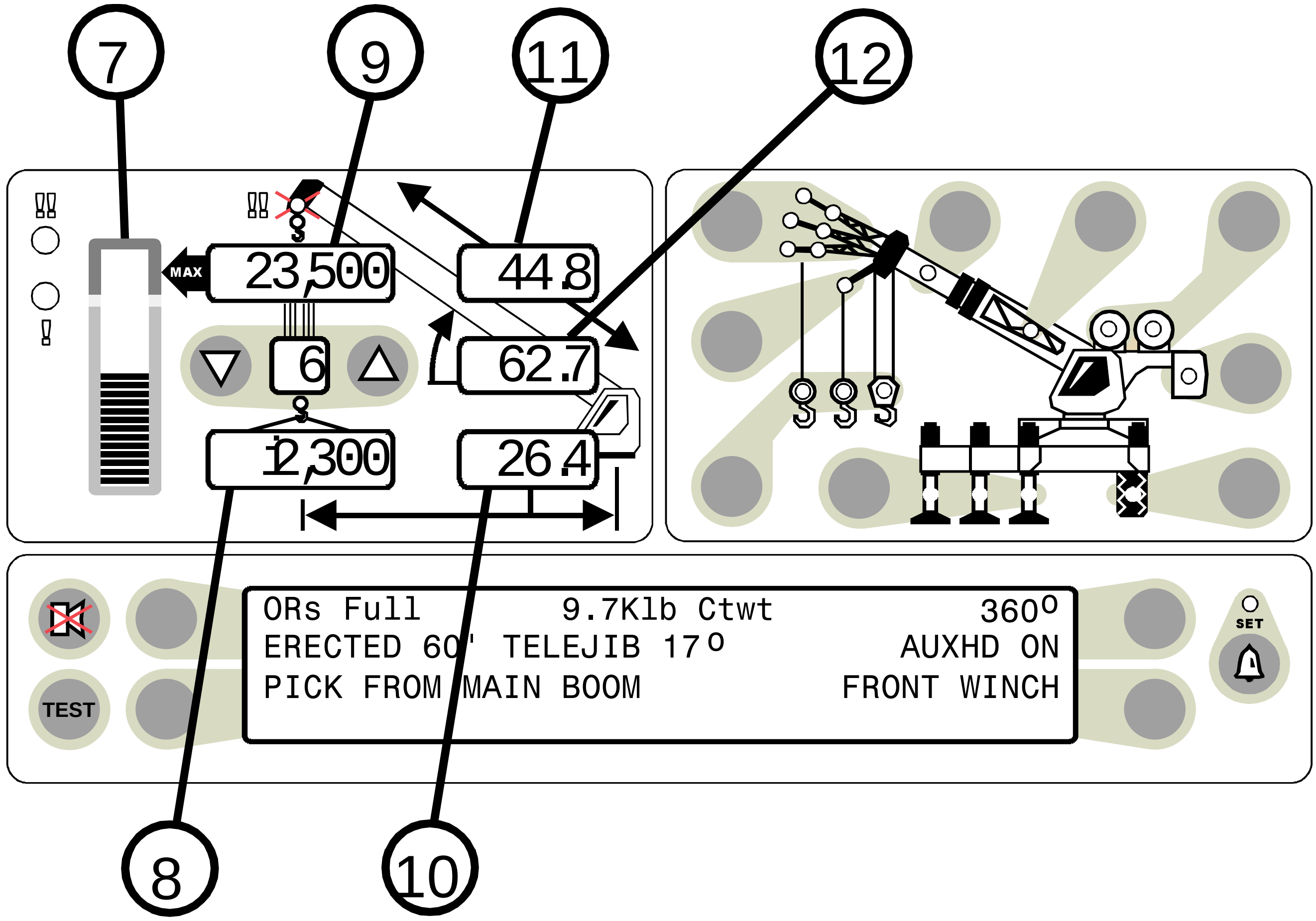
POINT OF LIFT - contains 3 LEDs. One will illuminate to show the point of lift.

WHAT DOES IT TELL YOU?



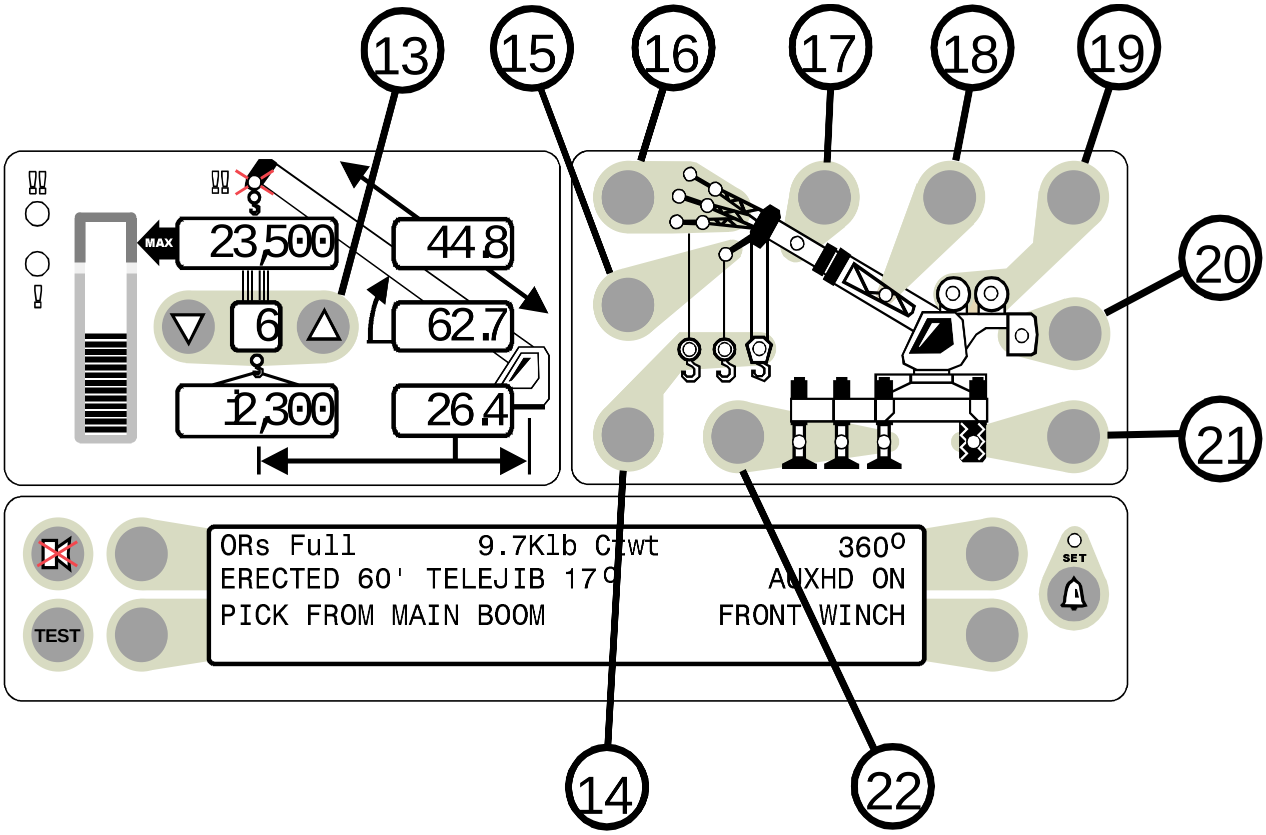
1. The **INFORMATION SCREEN** contains details of the currently selected configuration.
2. **PARTS-OF-LINE** displays the parts of line currently selected.
3. The **OPERATOR ALARM** lamp illuminates when operator alarms have been set.
4. The **PRE-ALARM (AMBER)** indicator illuminates at a preset value of 90% of Rated Capacity and provides a visual indication of approach to overload.
5. The **OVERLOAD INDICATOR (RED)** illuminates at a preset value of 100% of Rated Capacity and provides a visual indication of Maximum Allowed Load.
6. The **ANTI TWO-BLOCK** lamp illuminates when the A2B limit switch detects approach to a Two-Block condition.

WHAT DOES IT TELL YOU?



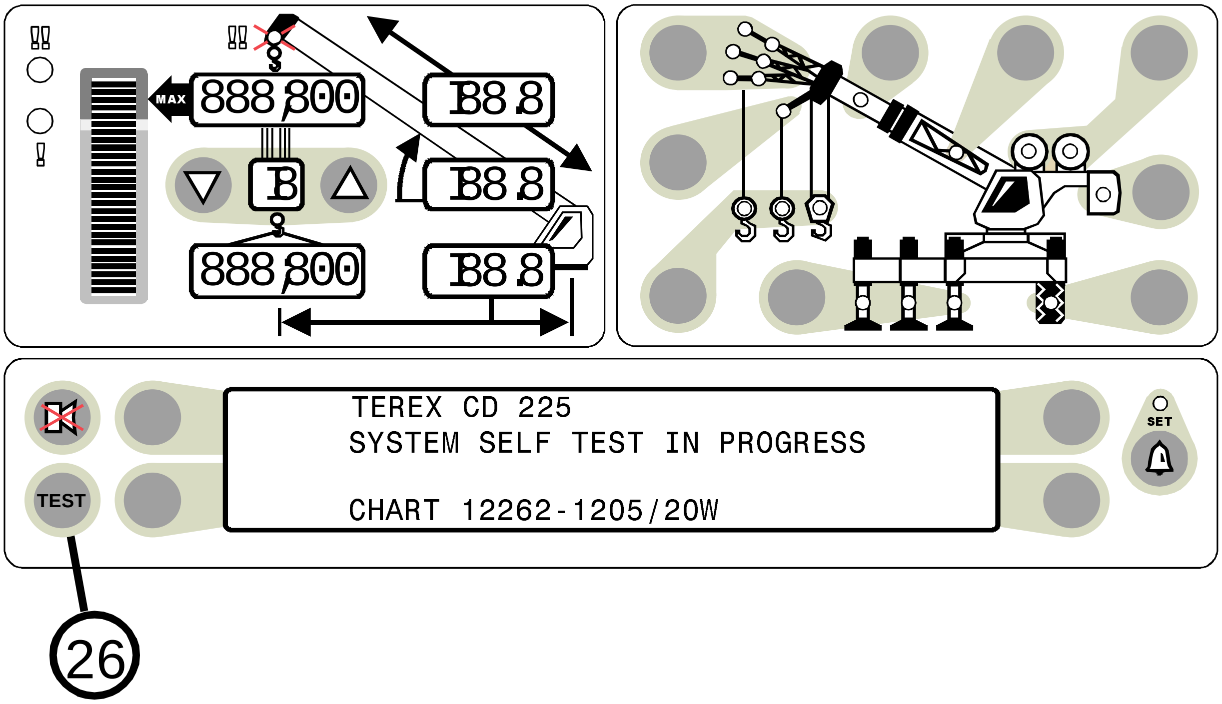
7. The **BAR GRAPH** indicates the ACTUAL LOAD as a PERCENTAGE OF RATED CAPACITY.
8. The **ACTUAL LOAD** display shows total load, including load, slings, etc. suspended below the lifting point.
9. The **RATED CAPACITY** display shows the RATED CAPACITY of the crane in the current configuration.
10. The **RADIUS** display shows radius of the load. Radius is the horizontal distance from the centerline of rotation to the centerline of the lifting point.
11. The **LENGTH** display shows the length of the main boom from the boom foot pin to the sheave pin of the main boom head machinery.
12. The **ANGLE** display indicates, in degrees, the angle of the main boom relative to horizontal.

WHAT MUST YOU TELL IT?



13. The number of **PARTS-OF-LINE**.
14. **POINT OF LIFT**, e.g. main boom, auxiliary head or jib.
15. **AUXILIARY HEAD** ON or OFF the crane.
16. Indicates **JIB** configuration in use.
17. **MANUAL SECTION** or **ACTIVE TIP** extended (if applicable).
18. **JIB STOWED ON BOOM**.
19. Indicates which **WINCH** will be used for the pick.
20. Indicates which **COUNTERWEIGHT** is fitted (if applicable).
21. **TIRES** creep, static, 2 1/2 MPH, and **RIGGING/TRAVEL** mode.
22. **OUTRIGGERS** full extension, mid extension, or retracted.

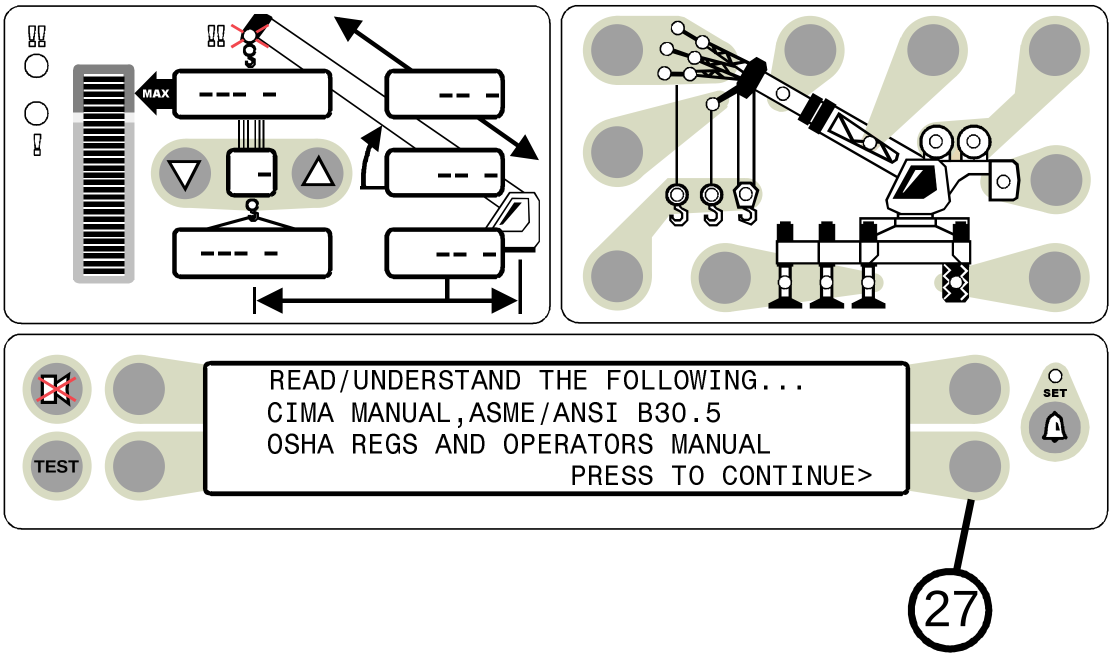
POWER UP SELF-TEST



Immediately following electrical power up or following operation of the **TEST** switch (item 26), the system executes a self-test that last for 8 seconds. During this time, the numerical display segments and bar graph segments are all turned on, the audible alarm will sound, and alarm indicator lights are illuminated.

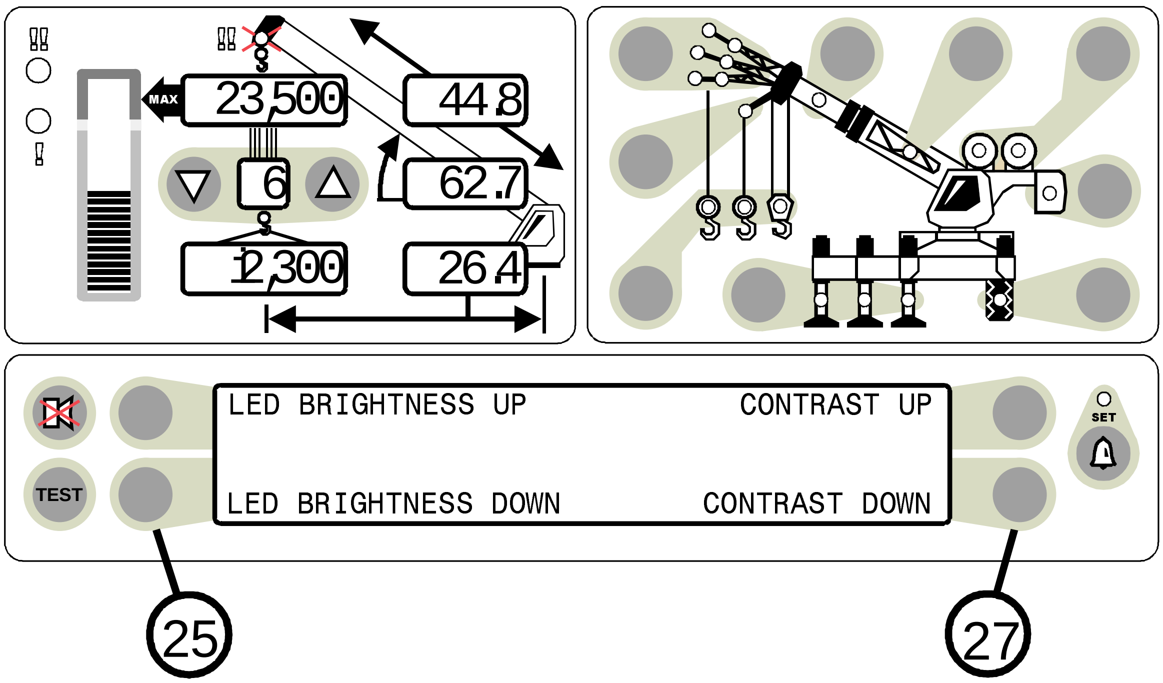
The information display shows the crane model and rating chart number.

START UP SCREEN



Immediately following power up self-test, the display indications will show as above. During this time, crane motions are disabled by the system function kickout. Operation of the bottom right information display push button (item 27) will acknowledge the information display message and allow the system to start normal operation.

BRIGHTNESS AND CONTRAST CONTROLS



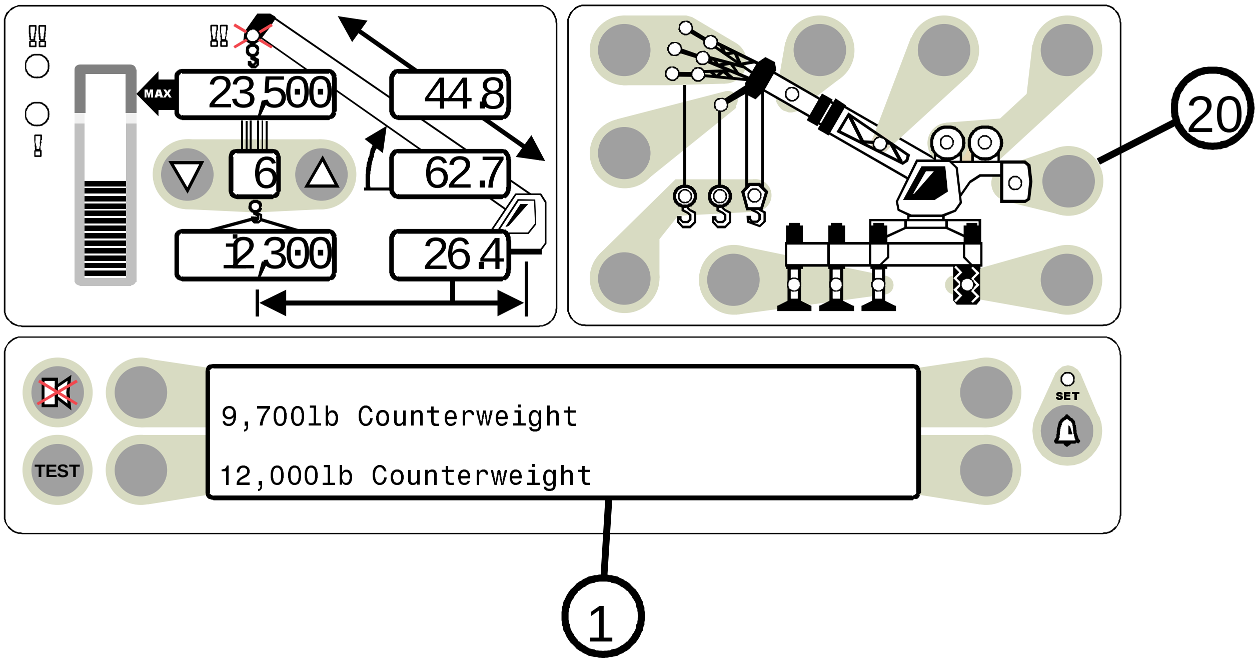
Immediately following self-test and the start up screen, the information display will display a 2 second reminder of the brightness and contrast control functions.

Push buttons to the left of the information display (item 25) allow the brightness of all LED's on the display panel to be adjusted up or down at any time during operation of the system unless operator alarms are being set.

Push buttons to the right of the information display (item 27) allow the contrast of the information display to be adjusted up or down at any time during operation of the system unless operator alarms are being set.

During adjustment of the contrast or brightness, the information window will automatically display the reminder window shown.

SYSTEM SETUP

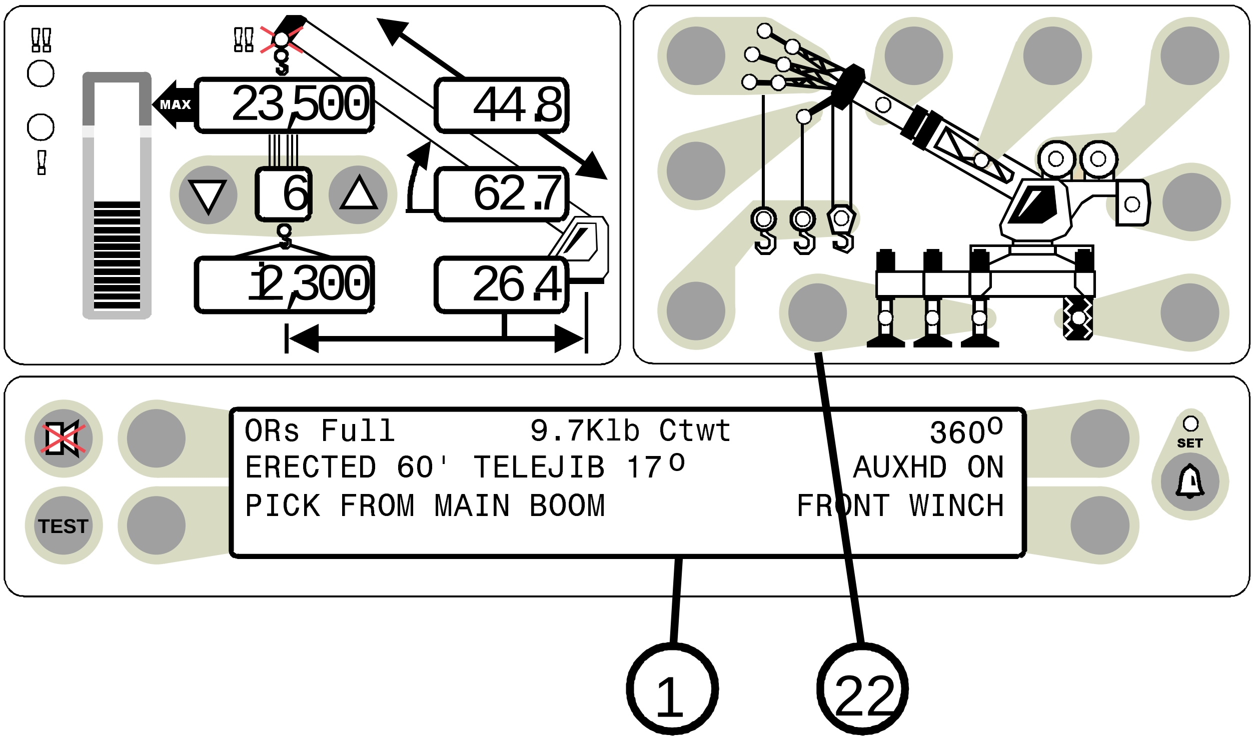


COUNTERWEIGHT

IF THE COUNTERWEIGHT PUSH BUTTON IS PRESSED ON A CRANE THAT DOES NOT HAVE COUNTERWEIGHT OPTIONS, THE MESSAGE **"NO OTHER COUNTERWEIGHT OPTIONS"** WILL APPEAR IN THE INFORMATION DISPLAY. REFER TO YOUR **CRANE RATING MANUAL** FOR DETAILS OF THE OPTIONS ON YOUR CRANE

- On cranes that have counterweight options the operator must tell the MicroGuard® System which counterweight is currently fitted. If there are no options, continue on to selection of outriggers.
- Start the choice by pressing the **counterweight push button** (item 20).
- The available counterweight options will be displayed in the information screen (1). There can be four options displayed at a time, one next to each selection key.
  - If the required option is visible, select the option by pressing the button next to it.
  - If more than 4 options are available, a second selection screen can be viewed by pressing the button next to the "next" label.
  - If only a single option is available, it will automatically be selected.

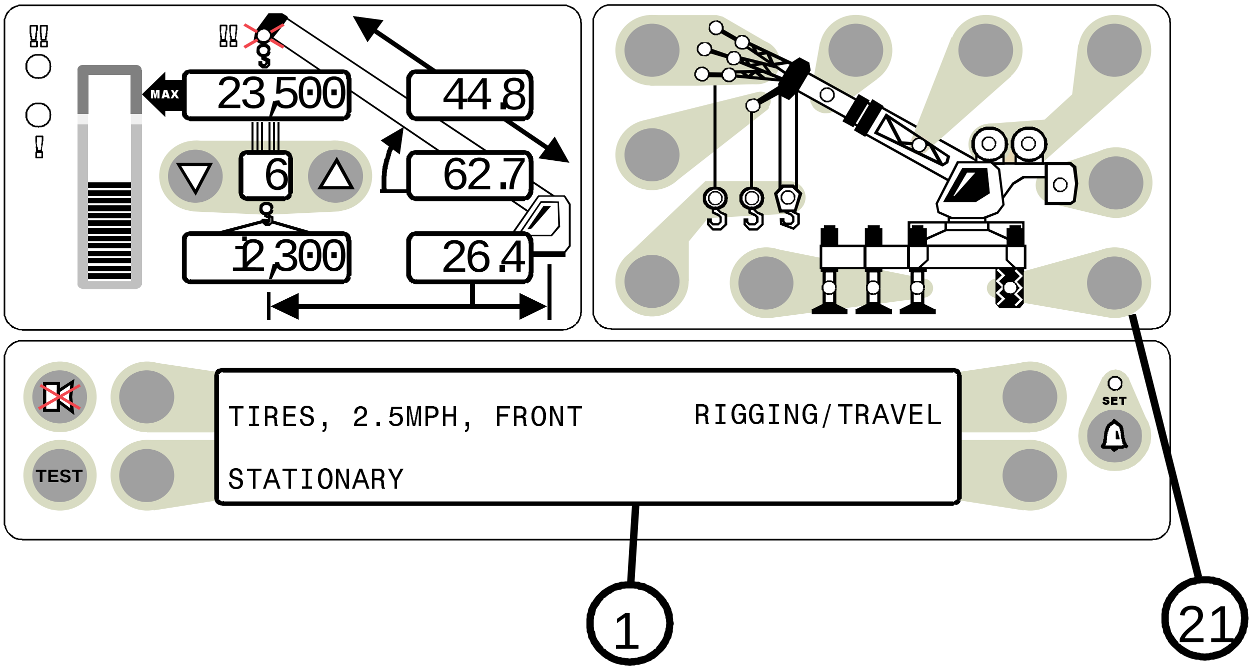
SYSTEM SETUP



OUTRIGGERS

- The operator must tell the system which outrigger position is in use.
- Start the choice by pressing the **outrigger push button** (item 22).
- The outrigger selection will automatically move on to the next selection.
  EXAMPLE:
  From fully extended to half extended, or from half-extended to fully retracted and then back to fully extended with each push of the button. If no other selections are available, the message "No other chassis options" will appear on the information screen (item 1).

SYSTEM SETUP



TIRES/RIGGING TRAVEL

IF THE TIRE PUSH BUTTON IS PRESSED ON A CRANE THAT DOES NOT HAVE TIRE OPTIONS THE MESSAGE **"NO OTHER TIRE OPTIONS"** WILL APPEAR IN THE INFORMATION DISPLAY. REFER TO YOUR CRANE RATING MANUAL FOR DETAILS OF THE OPTIONS ON YOUR CRANE.

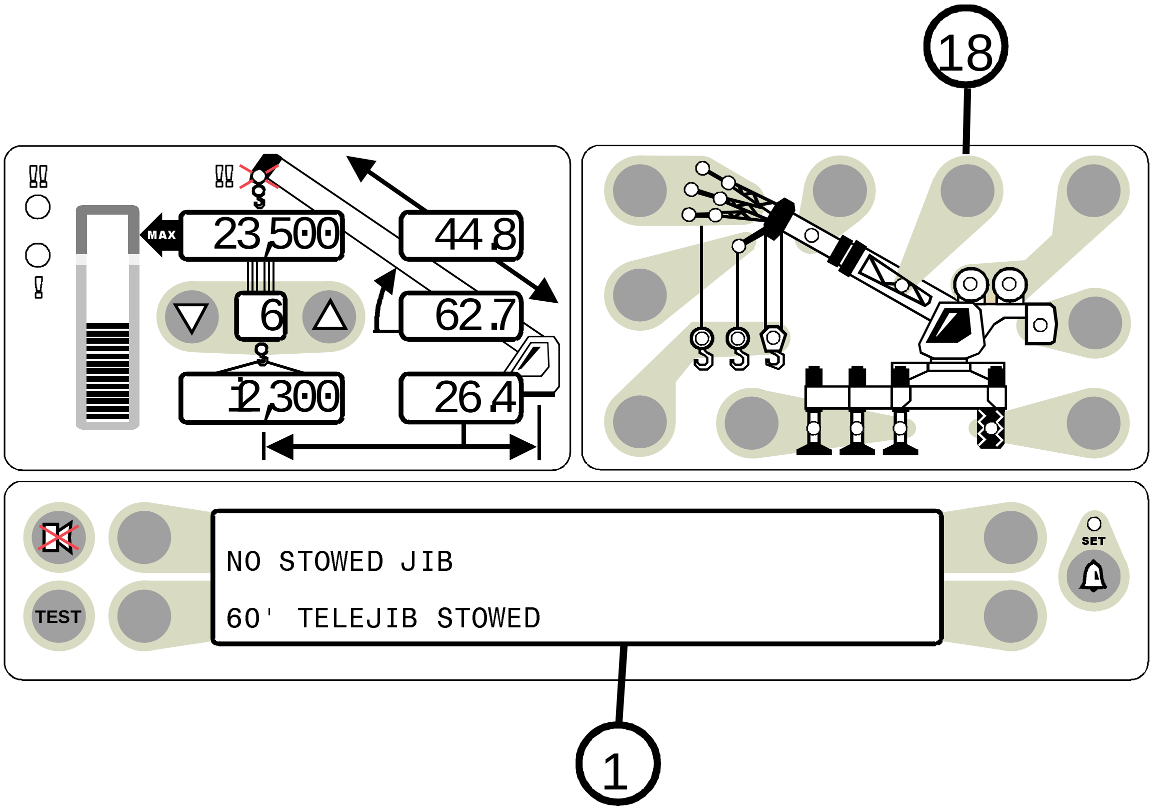
- On cranes that have more than one tire option, e.g. static, creep etc., the operator must select the tire configuration that corresponds to the tire chart to be used.
- Start the choice by pressing the **tire push button** (item 21).
- The available tire selection options will be displayed in the information screen (item 1). There can be four options displayed at a time, one next to each selection key.
  - ➢ If the required option is visible, select the option by pressing the button next to it.
  - ➢ If more than 4 options are available, a second selection screen can be viewed by pressing the button next to the "next" label.
  - ➢ If only a single option is available, it will automatically be selected.
- **RIGGING/TRAVEL MODE** is selected when the crane is in the rigging process or is a rough terrain crane traveling between jobs.

WARNING

DO NOT PERFORM CRANE LIFTING OPERATIONS WHILE THE RIGGING/TRAVEL MODE IS SELECTED.

ALL CRANE CONTROLS REMAIN ACTIVE WHILE THE RIGGING/TRAVEL MODE IS SELECTED.

SYSTEM SETUP

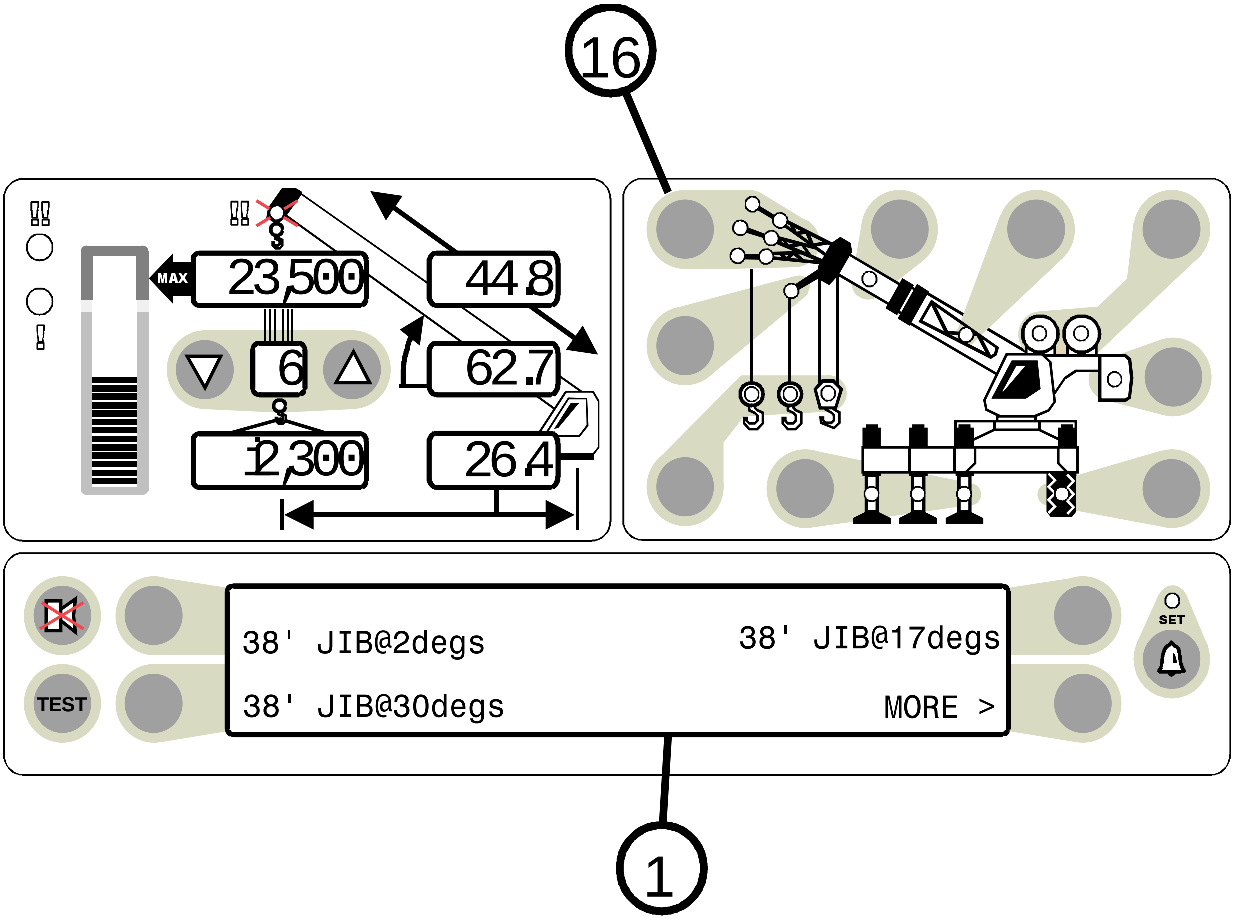


STOWED JIBS

IF THE STOWED JIB PUSH BUTTON IS PRESSED ON A CRANE THAT DOES NOT HAVE JIB OPTIONS, THE MESSAGE **"NO OTHER STOWED OPTIONS"** WILL APPEAR IN THE INFORMATION DISPLAY. REFER TO YOUR CRANE RATING MANUAL FOR DETAILS OF THE OPTIONS ON YOUR CRANE.

- On cranes that have more than one jib option (fixed, offset, or telejib etc.), the operator must select the jib to be used.
- Start the choice by pressing the **stowed jib push button** (item 18).
- The available stowed jib options will be displayed in the information screen (1). There can be four options displayed at a time, one next to each selection key.
  - If the required option is visible, select the option by pressing the button next to it.
  - If more than 4 options are available, a second selection screen can be viewed by pressing the button next to the "next" label.
  - If only a single option is available, it will automatically be selected.

SYSTEM SETUP



ERECTED JIBS

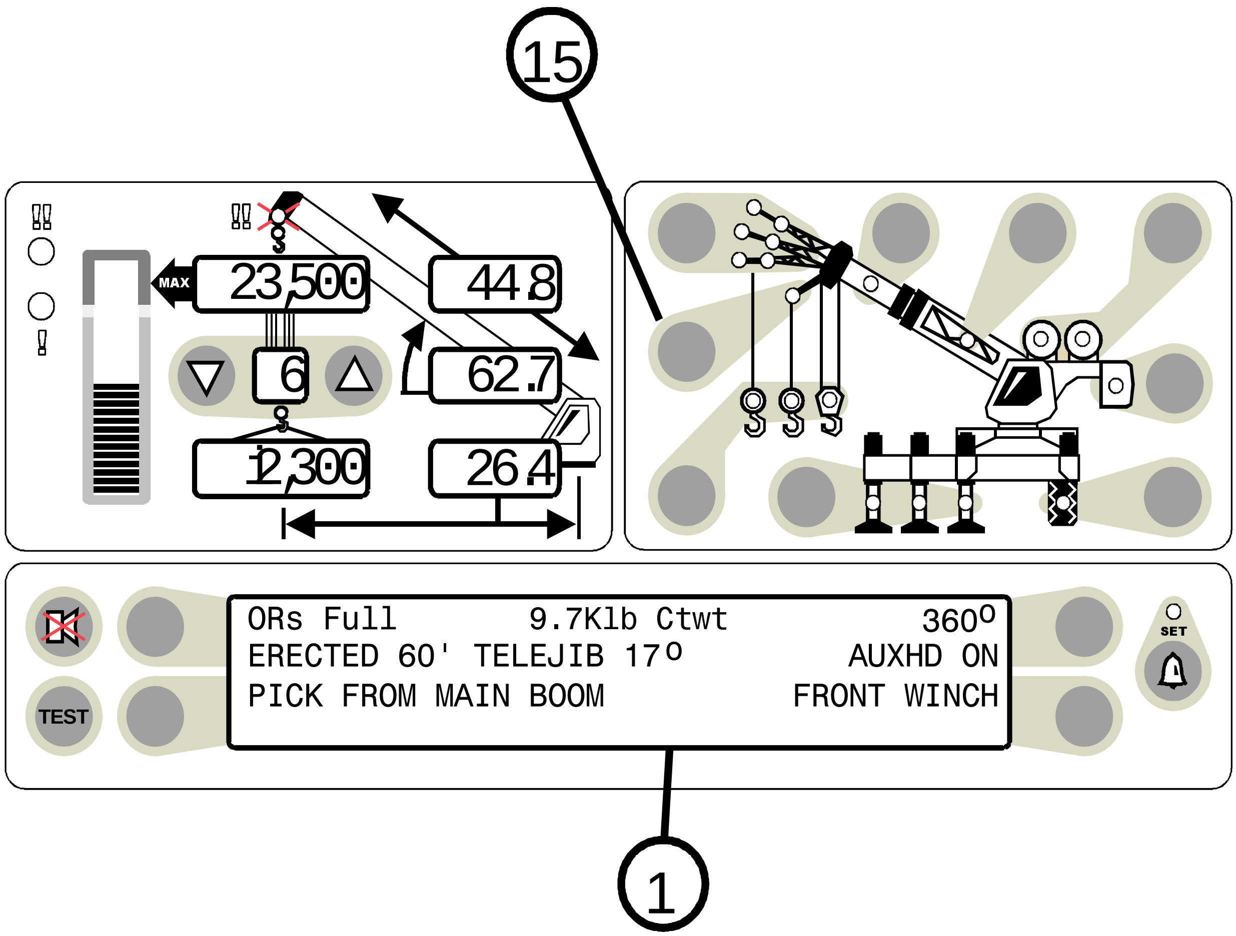
IF THE ERECTED JIB PUSH BUTTON IS PRESSED ON A CRANE THAT DOES NOT HAVE JIB OPTIONS, THE MESSAGE **"NO OTHER JIB OPTIONS"** WILL APPEAR IN THE INFORMATION DISPLAY. REFER TO YOUR CRANE RATING MANUAL FOR DETAILS OF THE OPTIONS ON YOUR CRANE.

- To erect a JIB, it must first have been selected and stowed as detailed on the previous page.
- Start the choice by pressing the **erected jib push button** (item 16).
- The available erected jib options will be displayed in the information screen (item 1).

There can be four options displayed at a time, one next to each selection key.

- ➢ If the required option is visible, select the option by pressing the button next to it.
- ➢ If more than 4 options are available, a second selection screen can be viewed by pressing the button next to the "next" label.
- ➢ If only a single option is available, it will automatically be selected.

SYSTEM SETUP



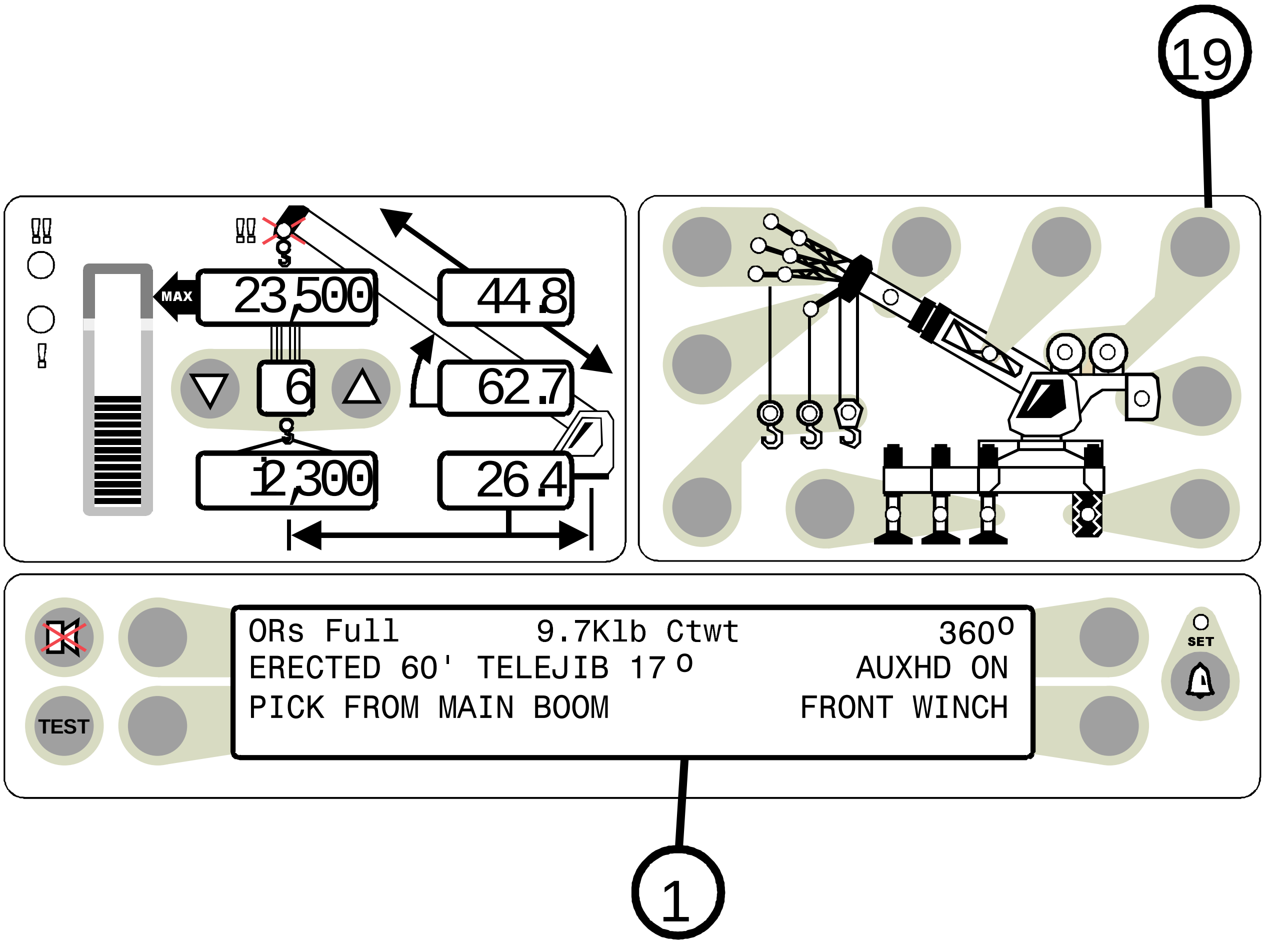
AUXILIARY HEAD

IF THE AUXILIARY HEAD PUSH BUTTON IS PRESSED ON A CRANE THAT DOES NOT HAVE AN AUXILIARY HEAD, THE MESSAGE **"NO OTHER AUXILIARY HEAD OPTIONS"** WILL APPEAR IN THE INFORMATION SCREEN (ITEM 1).

An auxiliary head fitted on a crane must be included in the crane setup.

To set up the crane with an auxiliary head, press the **auxiliary head push button**, (item 15). This will toggle the auxiliary head on and off each time the button is pressed.

SYSTEM SETUP



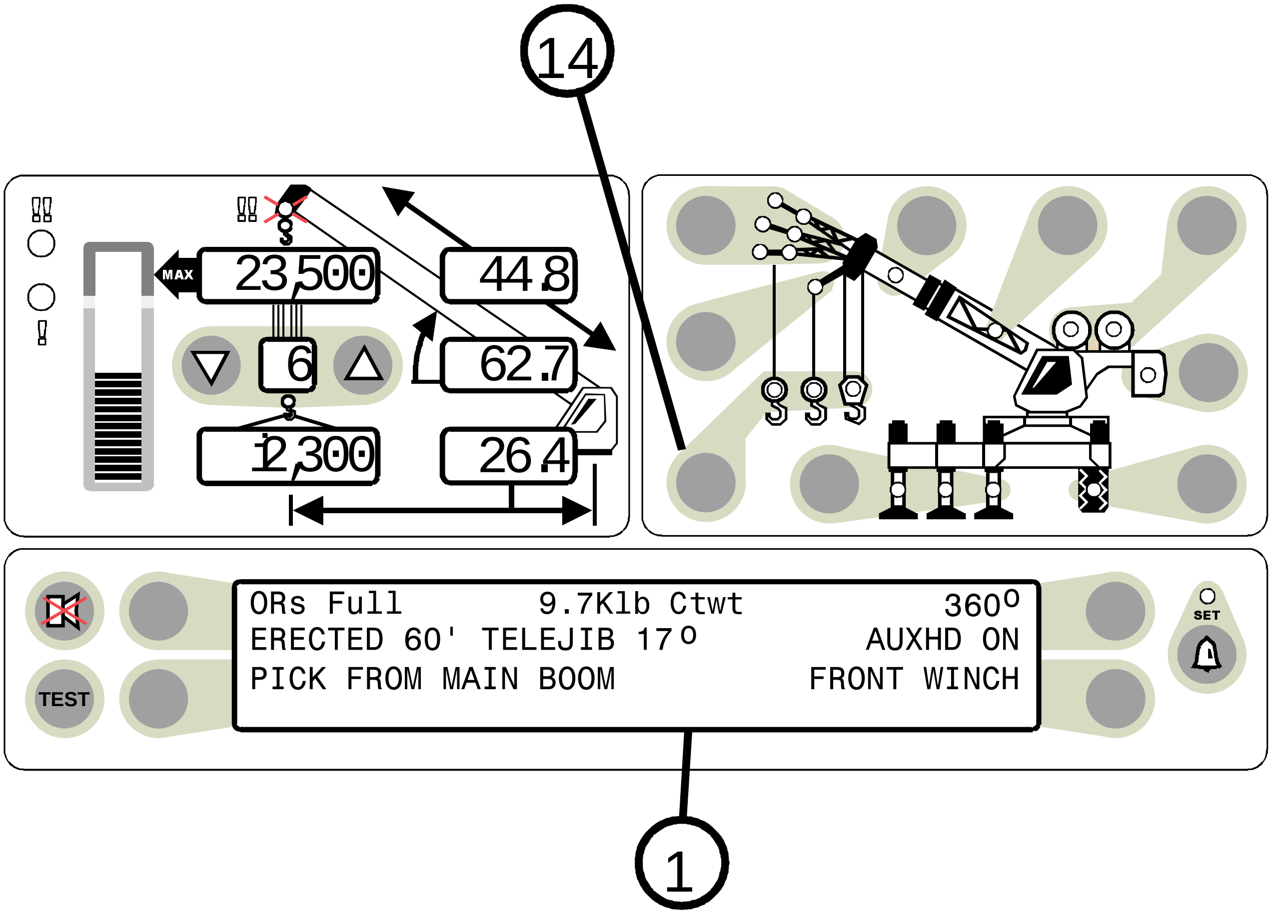
CHOOSING THE WINCH

For cranes with two winches, always select the winch to be used for the lift before selecting the point of lift and parts of line. The system stores point of lift and parts of line selections for each winch.

- Choose the winch to be used by pressing the **winch push button** (item 19).

This toggles between the two available winches each time the button is pressed. If no other winch is available, the message "No other winch options" will appear for three seconds on the information screen (item 1).

SYSTEM SETUP



CHOOSING THE POINT OF LIFT

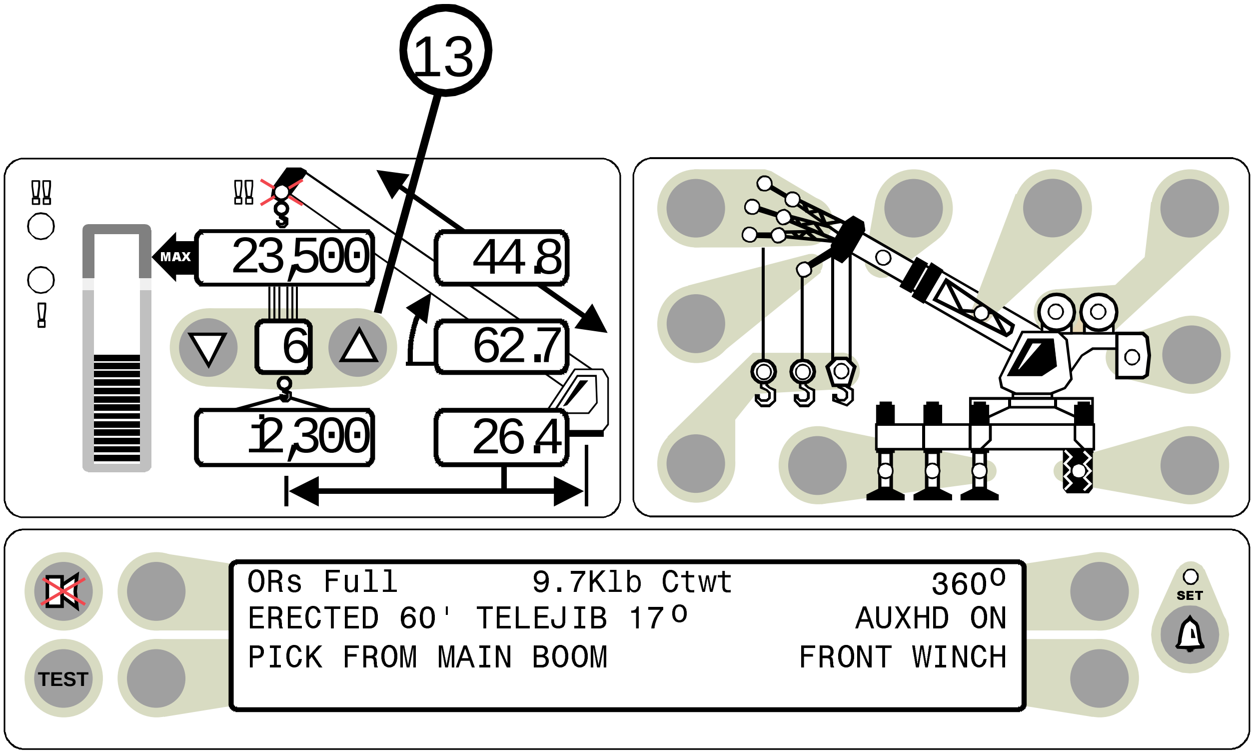
Before choosing the point of lift, check that the correct winch has been selected.
Always check the point of lift selection following selection of the winch.

- Choose the point of lift to be either from the main boom, auxiliary head, or jib by pressing the **point of lift push button** (item 14). This action moves the selected lifting point to the next available lifting point, i.e. from jib to aux head, from aux head to main boom, and from main boom back to jib again.

➢ If an option is not available, it will be skipped over.

➢ If no other pick point options are available, the message "No other pick point options" will be displayed on the information screen (item 1).

SYSTEM SETUP

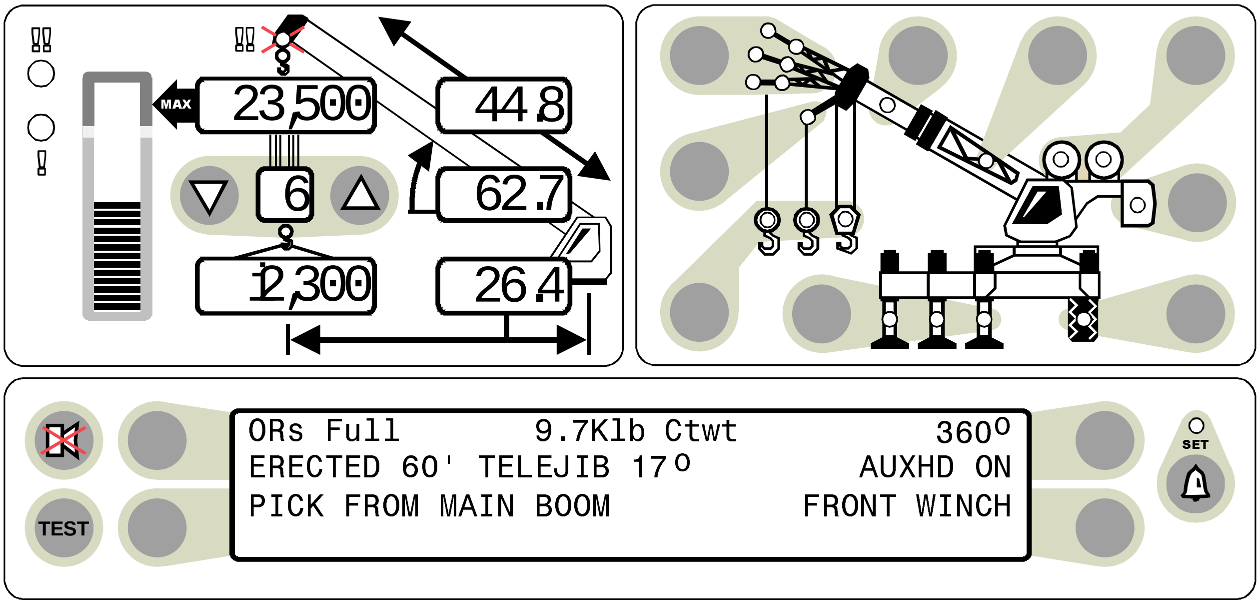


SETTING THE PARTS-OF-LINE

Always check and select parts-of-line following selection of the winch and point of lift.

- Set the **PARTS-OF-LINE** for the currently selected winch by pressing the UP or DOWN arrow, as appropriate. (item 13).
- The number of parts-of-line will appear in the parts-of-line display (item 13).
- When another winch is selected, it may be necessary to reset the parts-of-line for the other winch.
- When the number of parts in the parts-of-line on the crane is changed, it will be necessary to reset the parts-of-line on the display.

SYSTEM SETUP

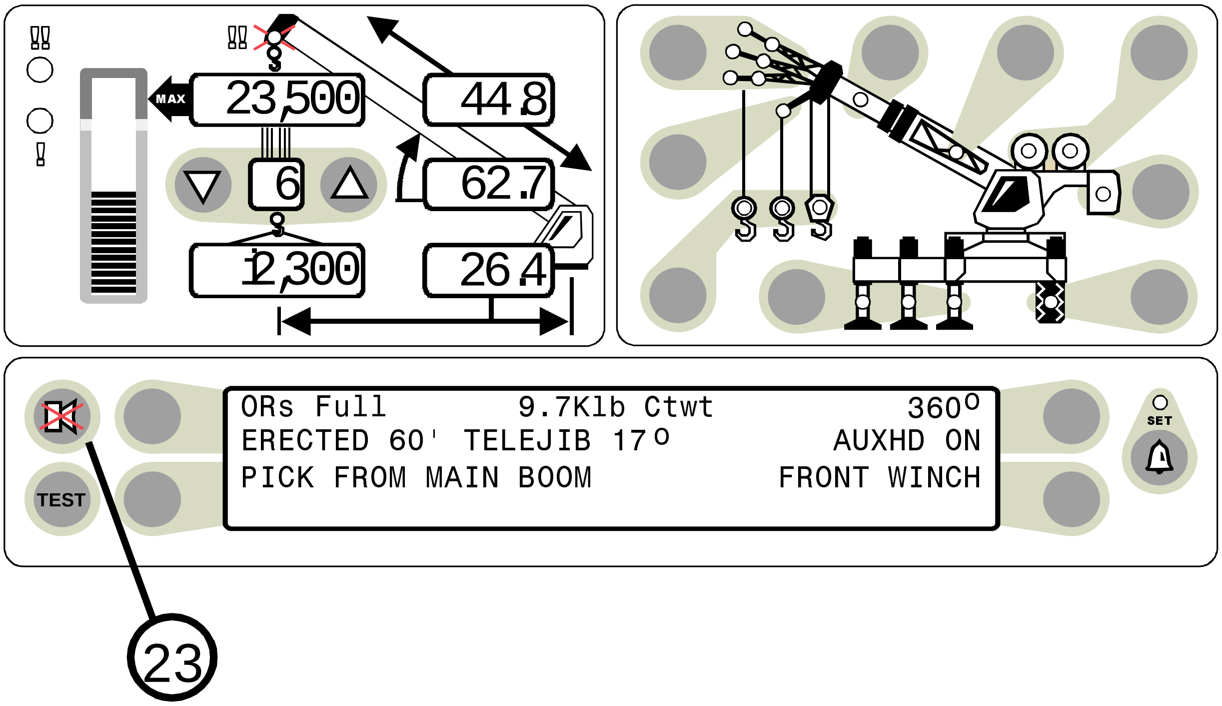


NOTES

The system has the capability of remembering all of the configuration data previously set. After removing power to the system and then powering up again, the settings remain intact until reset by the operator.

- ***After the configuration has been set, the operation of the System depends only upon setting which winch is in use. Changing the winch will automatically change the lifting point and the parts-of-line to the values previously set for the selected winch. Always check the point of lift and parts-of-line following selection of the winch.***

CANCEL AUDIBLE ALARM



PUSH BUTTON TO CANCEL AUDIBLE ALARM

The **cancel alarm push button** (item 23) is used to silence the audible alarm. **Pressing this button once will cancel an audible alarm that has occurred as a result of an:**

Overload

A2B Alarm

Operator Settable Alarm

The audible alarm remains canceled until the condition that caused the alarm has been removed. **See page 23.**

EXAMPLES:

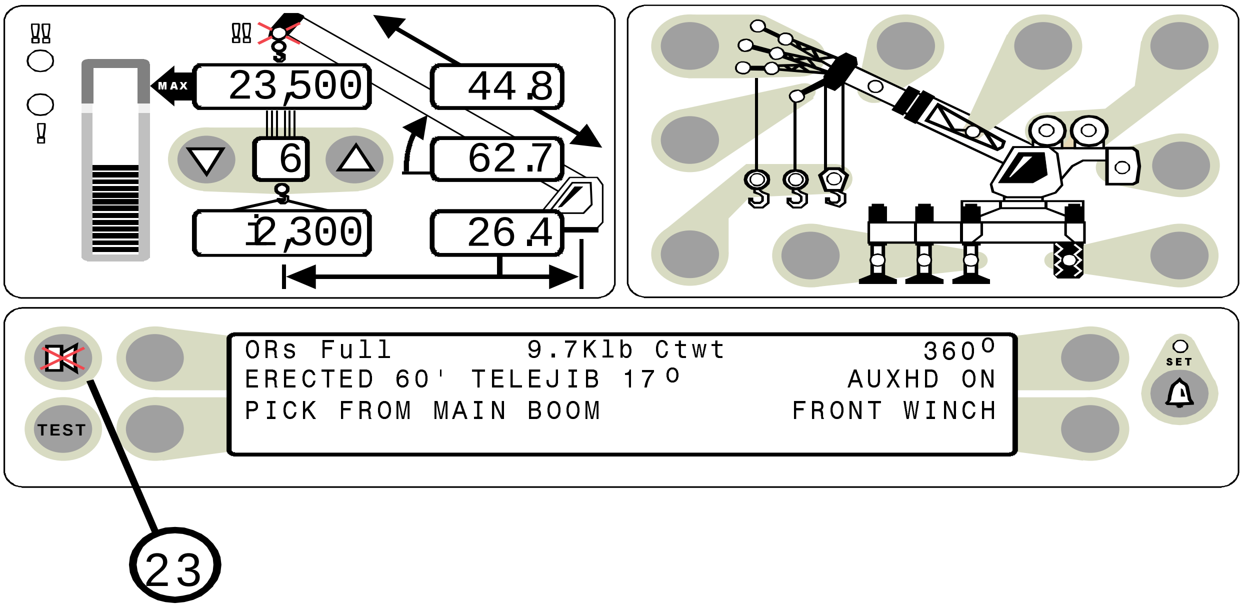
AFTER CANCELING AN AUDIBLE ALARM:

- If the audible alarm sounded because of an overload condition, the alarm will remain canceled until the condition is corrected.
- If **another alarm condition occurs** that normally causes an alarm to sound (such as A2B) **or if a previous condition** (such as overload) **is removed and then recurs, the new alarm condition will cause the audible alarm to sound again.**

The CANCEL ALARM push button is also used to reset the function kick-out relay when it is necessary to bypass the function disconnects. **Examples of when it may be necessary to override a function disconnect condition are:**

If the boom hoist cylinder is fully extended, the pressure in it will rise. This will be seen by the system as an overload and will not allow the operator to boom down. Using the bypass is necessary in this situation to move away from the fully extended boom hoist cylinder position.

CANCEL AUDIBLE ALARM CONTINUED



RESET FUNCTION KICK-OUT

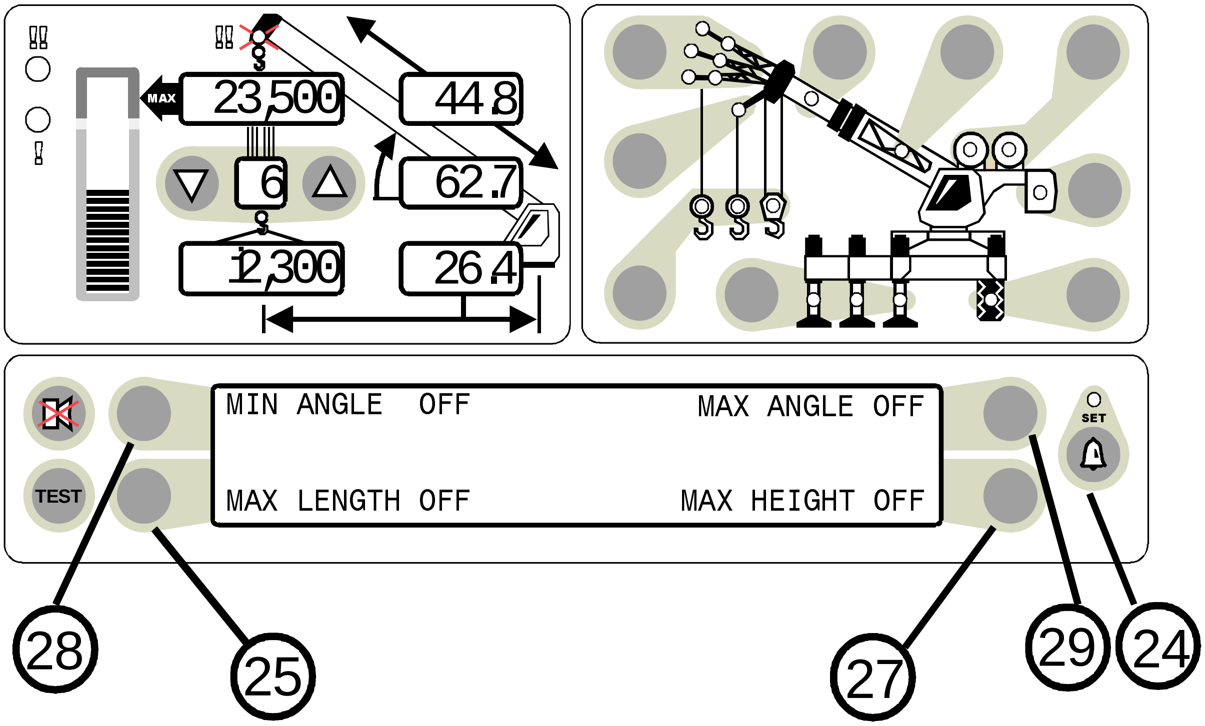
When the crane is to be rigged, it is often necessary to put the boom in a position that could cause function kick-out. Using the bypass is necessary in this situation.

Press and release and then press and hold the CANCEL ALARM push button (item 23) for approximately 5 seconds to reset the relay. At this time a second beep is heard confirming the bypass. When the condition that caused the alarm is no longer present, the function disconnect relay will reset to the normal condition. Should a different alarm condition occur while the relay is over-ridden, the new alarm condition will cause the controls to disconnect again.

WARNING

WHEN THE FUNCTION DISCONNECT RELAY IS RESET BY MEANS OF THE CANCEL ALARM PUSH BUTTON, THERE IS NO LONGER PROTECTION AGAINST THE CONDITION THAT CAUSED THE FUNCTION KICK-OUT.

OPERATOR SETTABLE ALARMS



ACCESSING THE OPERATOR ALARMS

To access the Operator Alarms from the main working screen, press the operator alarms push button (item 24). The Information Screen will then show the current status of the alarms.

The four operator alarms are shown below followed by the number identity of the push button that controls each alarm. These buttons are called out in the illustration above.

Minimum Boom Angle (item 28)

Maximum Boom Angle (item 29)

Maximum Boom Length (item 25)

Maximum Tip Height (item 27)

Each push button operates as a toggle switch turning the alarm "ON" or "OFF."

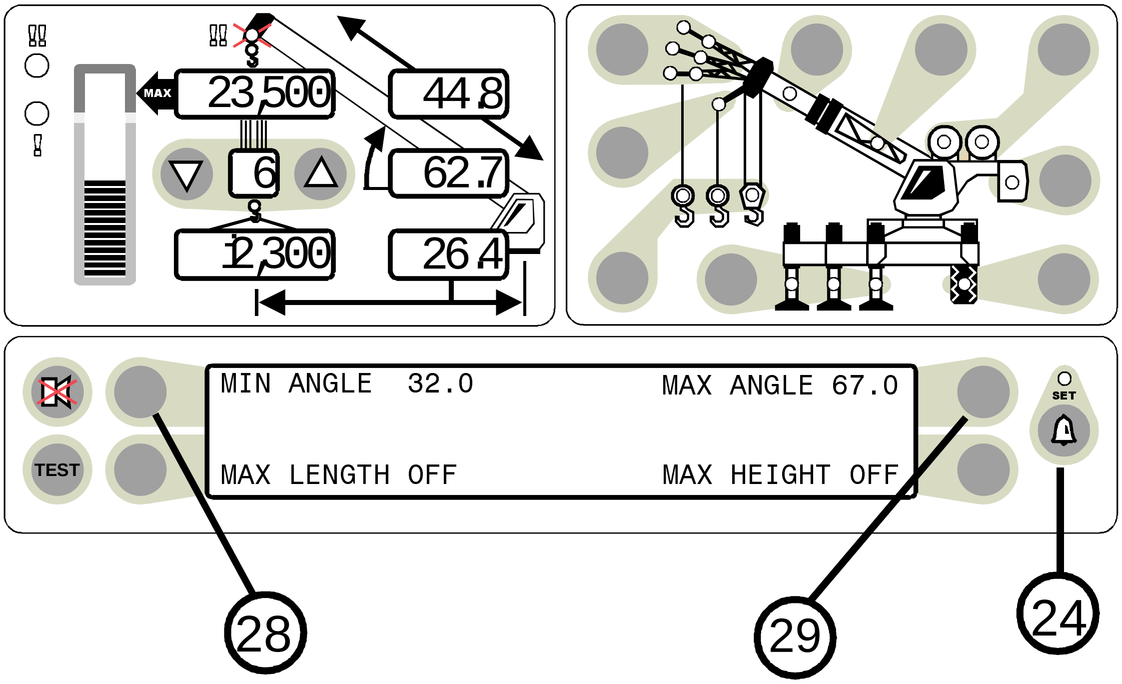
To activate or deactivate an alarm:

- If the alarm is OFF, press the appropriate push button to turn the alarm ON.
- If the alarm is ON, press the appropriate push button to turn the alarm OFF.

Refer to page 25 for a discussion on minimum and maximum boom angles and page 26 for maximum boom length and maximum tip height.

Return to the main screen by pressing the **operator alarm push button** (item 24) two times.

OPERATOR SETTABLE ALARMS CONTINUED



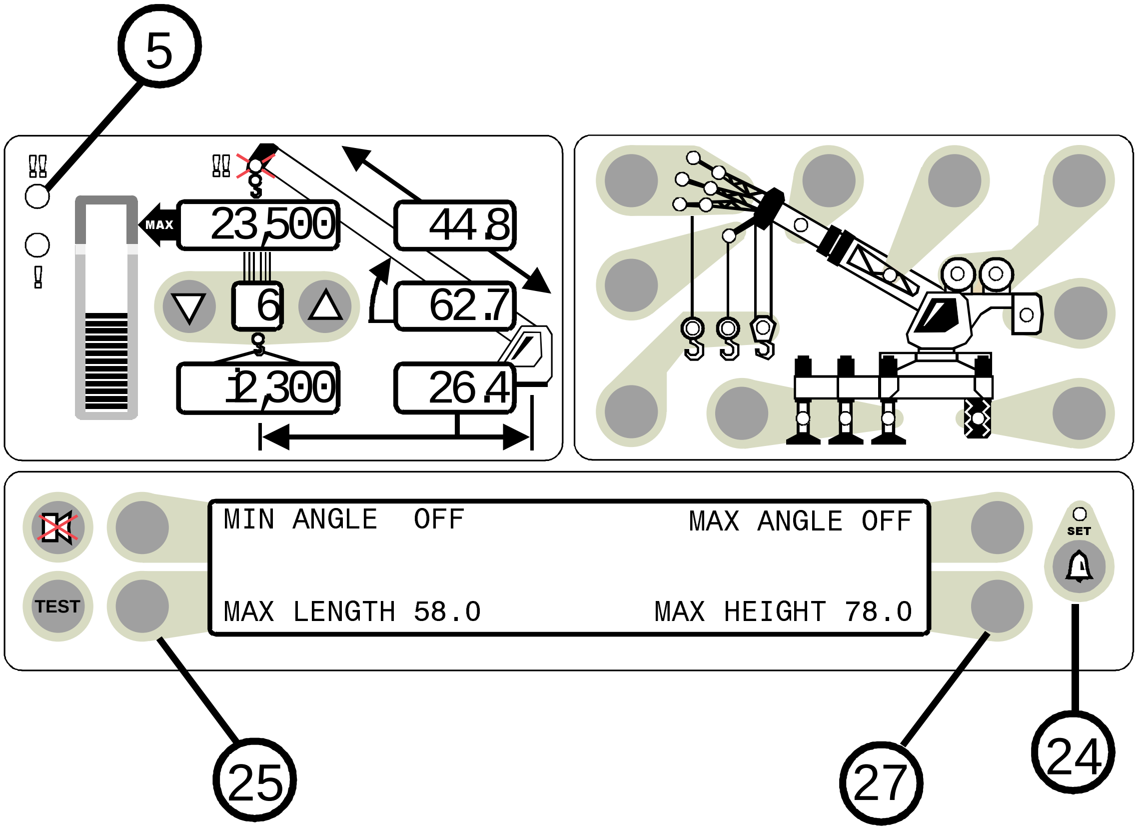
SETTING MINIMUM BOOM ANGLE ALARM

- Move the boom to the desired minimum angle (in this example 32°).
  Press the operator alarm push button (item 24) to access the operator alarm screen.
- Press the push button (item 28) pointing to Min Angle. In this example the display will read **MIN ANGLE 32°**.
- The red warning light (item 5) will flash and the audible alarm will sound whenever the boom angle is below 32°.
  Pressing the MIN ANGLE push button again will cancel the alarm and the display will read
  MIN ANGLE OFF

SETTING MAXIMUM BOOM ANGLE ALARM

- Move the boom to the desired maximum angle (in this example 67°).
- Press the operator alarm push button (item 24) to access the operator alarm screen.
- Press the push button (item 29) pointing to Max Angle. In this example the display will read **MAX ANGLE 67°**.
- The red warning light (item 5) will flash and the audible alarm will sound whenever the boom angle is above 67°.
  Pressing the MAX ANGLE push button again will cancel the alarm and the display will read MAX ANGLE OFF.

OPERATOR SETTABLE ALARMS CONTINUED



SETTING MAXIMUM BOOM LENGTH ALARM

- Move the boom to the desired maximum length, in this example 58 ft.
- Press the operator alarm push button (item 24) to access the operator alarm screen.
- Press the push button (item 25) pointing to Max Length. In this example the display will read **MAX LENGTH 58 FT**.
- The red warning light (item 5) will flash and the audible alarm will sound whenever the boom length exceeds 58 ft.

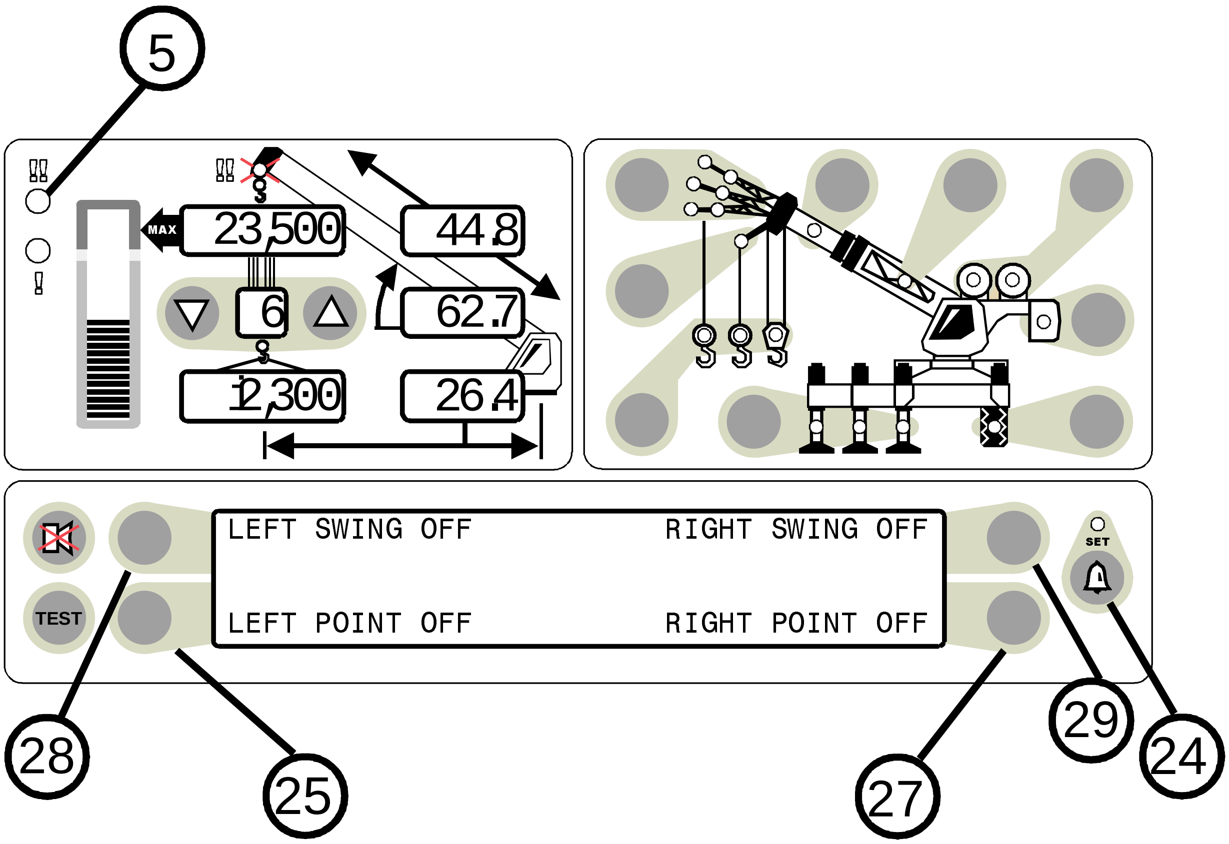
Pressing the MAX LENGTH push button again will cancel the alarm and the display will read MAX LENGTH OFF.

SETTING MAXIMUM TIP HEIGHT ALARM

- Move the boom to the desired maximum height, in this example 78 ft.
- Press the operator alarm push button (item 24) to access the operator alarm screen.
- Press the push button (item 27) pointing to Max Height. In this example the display will read **MAX HEIGHT 78 FT**.
- The red warning light (item 5) will flash and the audible alarm will sound whenever the boom tip height exceeds 78 ft.

Pressing the MAX HEIGHT push button again will cancel the alarm and the display will read MAX HEIGHT OFF.

OPERATOR SETTABLE ALARMS CONTINUED



ACCESSING SWING AND WORK AREA ALARMS

To access the SWING AND WORK AREA ALARMS from the main working screen, press the OPERATOR ALARM push button (item 24) 2 times.

The Information Screen will show the current status of the Swing and Work Area Alarms.

There are 4 separate operator alarms, all controlled by push buttons (items 25, 27, 28, and 29). Each one of these push buttons relates to the alarm to which it points.

Each push button operates as a toggle switch. If the alarm to be set is OFF, pressing the push button will turn the alarm ON. If the alarm to be set is ON pressing the push button will turn the alarm OFF.

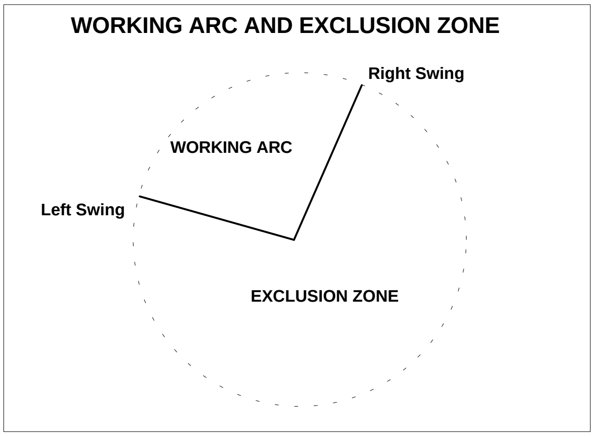
When Operator Alarms are set, the light in the push button (item 24) will be illuminated.

Return to the main screen by pressing the OPERATOR ALARM push button (24).

OPERATOR SETTABLE ALARMS CONTINUED

SWING ALARMS

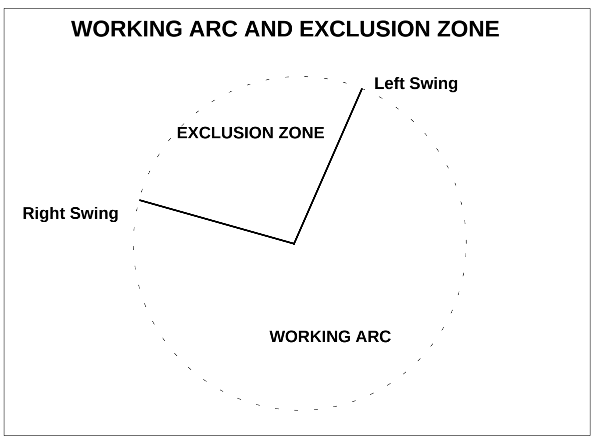
These alarms, when set, permit the operator to define a Working Arc and an Exclusion Zone by two set points. The following diagram illustrates the Working Arc and Exclusion Zone.



A left swing alarm is activated when swinging to the left.

A right swing alarm is activated when swinging to the right

*In this example, the working arc is the **smaller** piece of the pie.*



A left swing alarm is activated when swinging to the left.

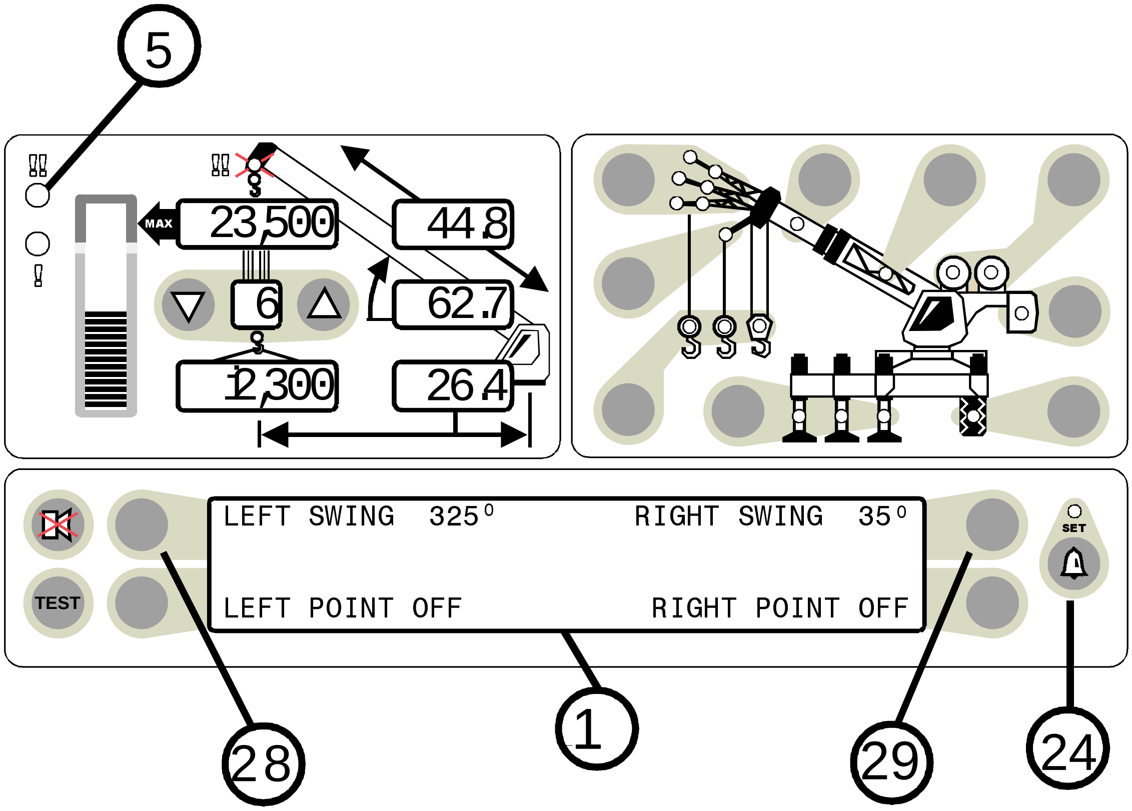
A right swing alarm is activated when swinging to the right

*In this example, the working arc is the **larger** piece of the pie.*

WARNING

THE OPERATOR DEFINED SWING ALARM IS A WARNING DEVICE. ALL FUNCTIONS REMAIN OPERATIONAL WHEN ENTERING THE OPERATOR DEFINED EXCLUSION ZONE. IT IS THE RESPONSIBILITY OF THE OPERATOR TO SET SWING ALARMS THAT ENSURE THAT THE CRANES BOOM, ATTACHMENT, LOAD, AND RIGGING ETC. MAINTAINS A SAFE WORKING DISTANCE FROM THE OBSTACLE. AVOID POSITIONING THE BOOM, ATTACHMENT, LOAD, AND RIGGING ETC. IN THE EXCLUSION ZONE WHEN MOVING TO THE LEFT AND RIGHT SWING POINTS. WHEN SELECTING LEFT AND RIGHT SWING POINTS ENSURE THAT THE LOAD WILL MAINTAIN A SAFE DISTANCE FROM THE OBSTACLE. IF THE CRANE OR OBSTACLE IS MOVED OR IF A DIFFERENT SIZE LOAD IS LIFTED THE SWING ALARMS MUST BE RESET.

OPERATOR SETTABLE ALARMS CONTINUED



SETTING LEFT SWING ALARM

- Swing the boom to the desired Left Swing Limit, e.g. 325°.
  Press the operator alarm push button (item 24) 2 times to access the swing alarm screen.
- Press the push button (item 28) pointing to Left Swing. The information screen (item 1) will read **LEFT SWING 325°.**

Both Left and Right Swing Alarms must be set for the system to operate correctly. The red warning light (item 5) will flash and the audible alarm will sound whenever only one of the left/right swing limits is set.

SETTING RIGHT SWING ALARM

- Move the boom to the desired Right Swing Limit, e.g. 35°.
- Press the Right Swing push button (item 29). The information screen (item 1) will read **RIGHT SWING 35°.**

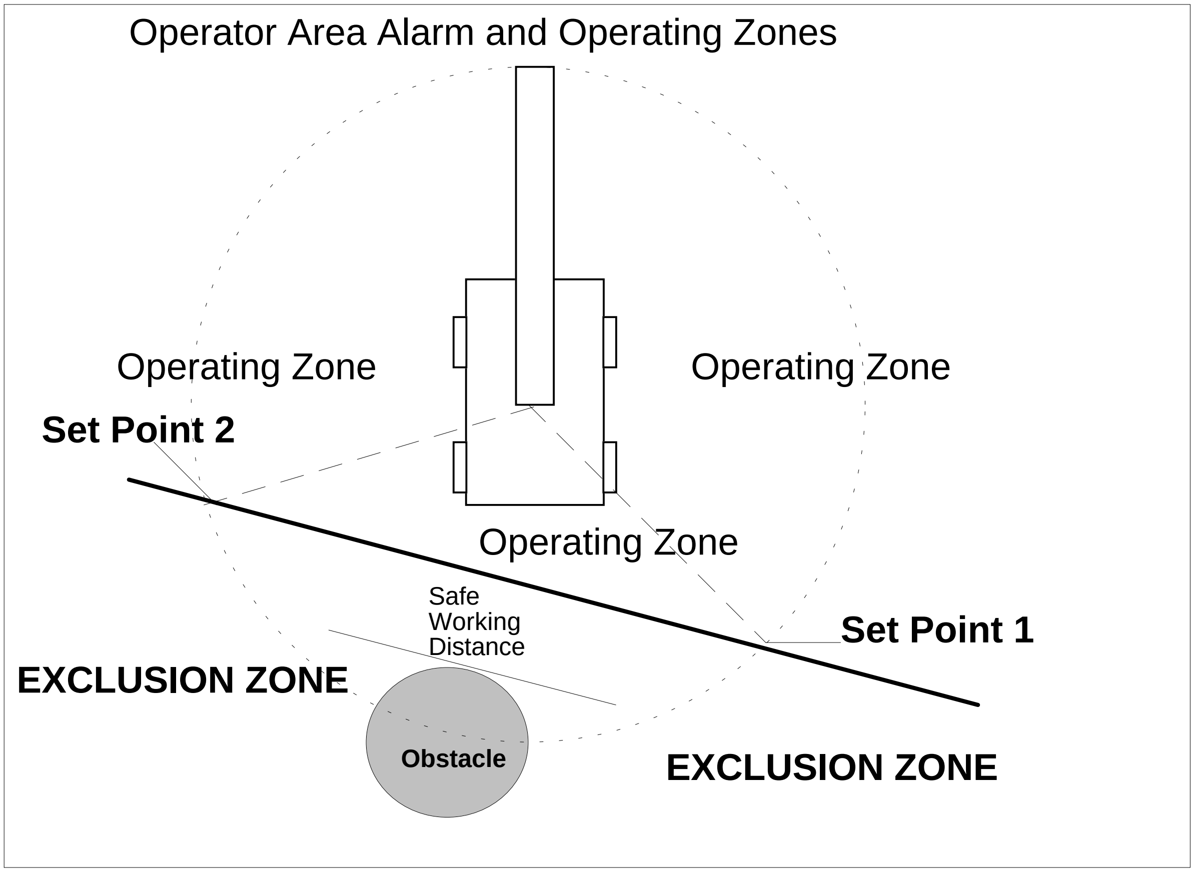
The red warning light (item 5) will flash and the audible alarm will sound whenever the boom swings past the preset limits.

Pressing the LEFT SWING and RIGHT SWING push buttons again will cancel the alarm and the information screen (item 1) will read:
LEFT SWING OFF RIGHT SWING OFF.

OPERATOR SETTABLE ALARMS CONTINUED

WORK AREA SELECTION MODE

This alarm, when set, permits the operator to define an Operating Zone by only two set points. The use of this method results in a greatly enhanced work area and also clearly and simply defines the Exclusion Zone area. The following diagram illustrates the Operating Zone and the Exclusion Zone.

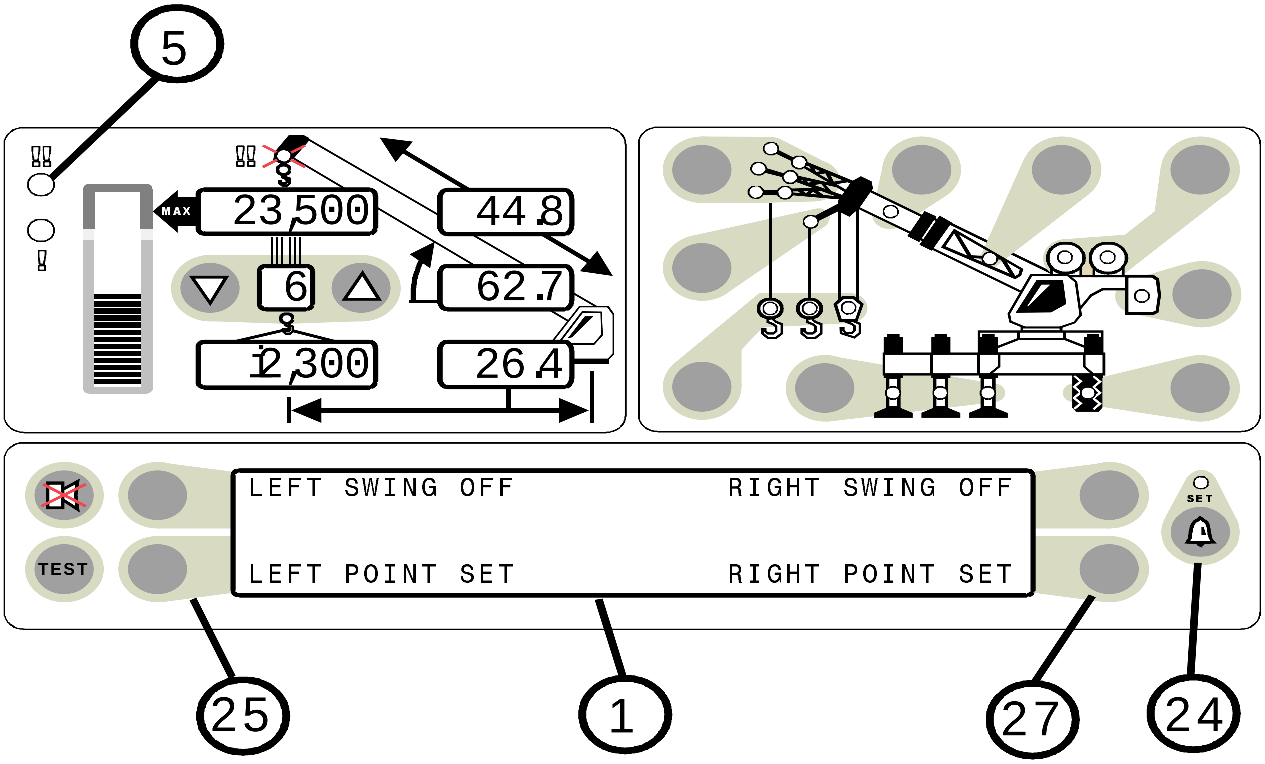


The operator defined work area alarm, when set, will define an imaginary vertical plane between two set points to optimize the working area. When passing the plane, the red warning lamp will illuminate, the audio alarm will sound, and the message “EXCLUSION ZONE” will flash on the display.

WARNING

THE OPERATOR DEFINED WORK AREA ALARM IS A WARNING DEVICE. ALL FUNCTIONS REMAIN OPERATIONAL WHEN ENTERING THE OPERATOR DEFINED EXCLUSION ZONE. “SAFE WORKING DISTANCE” IS THE TIME IT WOULD TAKE AN OPERATOR TO REACT TO AN ALARM AND FOR THE CRANE MOTION TO BE HALTED BEFORE ENTERING THE EXCLUSION ZONE. IT IS THE RESPONSIBILITY OF THE OPERATOR TO SET POINTS THAT ENSURE THAT THE CRANE BOOM, ATTACHMENT, LOAD, RIGGING, ETC. MAINTAINS A SAFE WORKING DISTANCE FROM THE OBSTACLE. AVOID POSITIONING THE BOOM, ATTACHMENT, LOAD, RIGGING, ETC. IN THE EXCLUSION ZONE WHEN MOVING TO SET POINTS 1 AND 2. WHEN SELECTING SET POINTS 1 AND 2, ENSURE THAT THE LOAD WILL MAINTAIN A SAFE DISTANCE FROM THE OBSTACLE. IF THE CRANE OR OBSTACLE IS MOVED, OR IF A DIFFERENT SIZE LOAD IS LIFTED, THE WORK AREA ALARM MUST BE RESET.

OPERATOR SETTABLE ALARMS CONTINUED



WORK AREA SELECTION MODE

- Press the operator alarm push button (item 24) two times to access the Work Area alarm screen.

SETTING POINTS 1 AND 2

- Move the boom, attachment, load, rigging etc. to the desired **LEFT SET POINT.**
- Press the push button (item 25) pointing to Left Point. The information screen (item 1) will read **LEFT POINT SET**.

Both Left and Right Points must be set for the system to operate correctly. The red warning light (item 5) will flash and the audible alarm will sound whenever only one of the left/right swing limits is set.

- Move the boom, attachment, load, rigging etc. to the desired **RIGHT SET POINT.**
- Press the push button (27) pointing to Right Point. The information screen (item 1) will read **RIGHT POINT SET.**

The red warning light (item 5) will flash and the audible alarm will sound whenever the boom tip penetrates the exclusion zone.

Pressing the **LEFT POINT** and **RIGHT POINT** push buttons (25 & 27) again will cancel the alarm and the information screen (item 1) will read

LEFT POINT OFF **RIGHT POINT OFF**

GLOSSARY OF TERMS

ACTUAL LOAD	The load suspended below the lifting point.
ALARM	A signal that warns or alerts, such as a flashing light or loud noise.
ANGLE SENSOR	A device that measures the inclination of a boom.
ANTI TWO-BLOCK	A device that, when activated, prevents movement that causes two-blocking.
AUDIBLE ALARM	A signal that alerts by means of noise.
AUXILIARY HEAD (AUXHD)	A short jib fitted at the main boom head that is used to provide separation of the main and auxiliary ropes when both are reeved over the main boom head.
AUXILIARY HOIST (AUX HOIST)	A separate hoist rope system other than the main hoist.
BARGRAPH	A pictorial device used to illustrate quantitative relationships.
BOOM	A member hinged to the upperstructure that supports the hoisting tackle.
BOOM ANGLE	The angle of the longitudinal axis of the boom relative to horizontal.
BOOM HOIST	A device for controlling the boom angle.
BOOM LENGTH	The length of the boom along its longitudinal axis from the foot pin to the axle of the head machinery.
BOOM MOMENT	The turning moment around the boom pivot caused by the moment of the unladen boom.
CAPACITY CHART	A table showing the rating of a crane.
CENTER LINE OF ROTATION	The vertical axis around which the crane upperstructure rotates.
CENTER OF GRAVITY	The point at which the entire weight of a body may be considered as concentrated so that if supported at this point the body would remain in equilibrium in any position.
COMMISSIONING	Preparing to be put into service.
CONFIGURATION	An arrangement of the lifting elements of a crane.

COUNTERWEIGHT (CTWT)	A weight used to supplement the weight of the crane to provide stability for lifting.
CURSOR	A pointer on a display that indicates the position where data is to be entered.
DEDUCT	A reduction in rated capacity for an **unused** stowed or erected attachment.
DIRECTION	The direction of rotation of the superstructure.
DUTY	A working configuration on a crane usually contained in a single column of a capacity chart.
ERECTED ATTACH-MENT	An attachment on the main boom fitted in its working position.
EXTENSION SENSOR	A device that measures the extension of the telescoping sections of a boom.
FUNCTION KICK-OUT	A device that disengages certain crane functions whose movement could cause overload or two-blocking.
HEIGHT	The vertical distance from the ground to the tip of the boom or attachment.
HORIZONTAL	Parallel to the horizon.
INFORMATION SCREEN	A display that gives information supplemental to the information on the pictograph.
INTEGRATED CIRCUITS	A tiny complex of electronic components and connections on a small slice of material (such as silicon).
JIB	Something attached such as a lattice fly or jib on a crane boom.
MANUAL SECTION	The tip section of the main boom that can be telescoped independently of the other sections.
MICROPROCESSOR	A computer processor contained on an integrated chip.
MOMENT	The product of force and distance to a particular axis or point.
OPERATOR ALARMS	Alarms that can be set by the operator, which provide working limits additional to the chart limits.
OUT OF DUTY	A point which is either longer than the longest permitted radius or lower than the lowest permitted angle on a capacity chart

OUTRIGGER (ORs)	A support projecting from a main structure used to provide additional stability.
OVERLOAD	The point at which the actual load exceeds the rated capacity of the crane.
PARTS OF LINE	The number of parts of hoist rope between the upper and lower blocks.
PICTOGRAPH	A pictorial representation of the crane.
POINT OF LIFT	The location of the hoist rope for the current lift e.g. main boom, auxiliary head or jib.
PRE-ALARM	The point at which the actual load is 90% of the rated capacity of the crane.
PRESSURE	Hydraulic pressure in the boom hoist cylinder
RADIUS	The horizontal distance from the centerline of rotation to the center of the hook.
RATED CAPACITY	The lifting capacity of a crane, as determined by the published capacity chart.
RATED CAPACITY	The load that a crane can safely handle based on factors such as strength, stability, and rating.
RATING	A factor determined by legislation that limits the proportion of the capability of the cranes that may be utilized in a lifting operation. Usually expressed as a percentage of strength or stability.
REEVING	A rope system in which the rope travels around drums and sheaves.
ROPE LIMIT	The maximum permitted single line pull determined by the construction and diameter of a wire rope.
ROPE LIMIT	A condition that occurs when the type of rope and the parts-of- line in use restrict the capacity of the crane.
SENSOR	A device that responds to physical stimulus and transmits a resulting impulse.
SHEAVE	A grooved wheel or pulley.
SLEW OFFSET	The horizontal distance from the boom pivot to the center of rotation
STOWED ATTACHMENT	An attachment usually stowed on the main boom when not in use.
UPPERSTRUCTURE	The structural part of a crane above the carrier, usually rotating.

SWING	The rotation of a crane upper around its center line.
SWING ALARMS	Audible alarms occurring when the upper structure swings into areas defined by the operator with the use of Operator Alarms.
SWL (%SWL)	Percentage of safe working load. The proportion of the crane capacity which is being utilized at any one time expressed as a percentage of rated capacity
TRANSDUCER	A device that is actuated by energy from one system and converts this to another form for use by a different system (as a loudspeaker, that is, actuated by electrical signals and supplies acoustic power).
TWO-BLOCKING	The condition when the lower load block or hook assembly comes in contact with the upper load block or boom point.
UNLADEN	A boom that has no additional stowed or erected attachments and that is not supporting a load.
WINCH	A hoist drum used in conjunction with a rope for raising and lowering loads.
WORK AREA ALARM	Permits the operator to define an operating zone by the means of only two set points.

MOBILE
POWER CRANE AND EXCAVATOR AND HYDRAULIC CRANE STANDARDS

PCSA STANDARD NO. 4

(supersedes PCSA Standards No. 1 and No. 2)

DEVELOPED AND COMPILED BY

PCSA

A Bureau of Construction Industry Manufacturers Association

MEMBER PCSA POWER CRANE AND SHOVEL ASSOCIATION

PCSA

A BUREAU OF CONSTRUCTION INDUSTRY MANUFACTURERS ASSOCIATION

The Power Crane and Shovel Association, formed in 1943 by United States manufacturers of power cranes and shovels, is one of the oldest and most respected manufacturer groups in the Construction Industry.

In 1962, the decision was made to operate under the sponsorship of the Construction Industry Manufacturers Association. The companies which made up the Power Crane and Shovel Association already were members of CIMA and this move resulted in closer contact with other segments of the Construction Industry. It also resulted in greater economy of operation without diminishing the benefits to its members.

PCSA has become recognized as the spokesman for the Industry in domestic and overseas activities and liaison with the Federal Government. Foremost among its activities has been the promotion of members' products on an overall Industry basis. Related to this has been the establishment and updating of Industry standards in keeping with the advances of technology in newer materials and methods to give the manufacturer, the owner and the operator meaningful guidelines

The publishing of Technical Bulletins and Manuals is an important function of the Association. Not only have these been well received by those directly connected with the Industry, but colleges and universities in this country and abroad have found them very desirable as technical reference books for classes being conducted in engineering studies. Many have been published in foreign languages.

This Publication which is one of a series, is an example of how the members of the Power Crane and Shovel Association have combined their efforts in a worthwhile project.

PCSA

FOREWORD

This standard and recommendations were developed by the Technical Committee of the Power Crane and Shovel Association (PCSA), a Bureau of the Construction Industry Manufacturers Association (CIMA). They are intended to encompass only mobile cranes described in the SCOPE.

Particular emphasis is placed on the latest recommended engineering practices and method of specification for the industry. Where applicable, reference to other technical standards and recommended practices are included. Acknowledgement for use of these is made to the following:

Society of Automotive Engineers
Off-Road Machinery Technical Committee
400 Commonwealth Drive
Warrendale, Pennsylvania USA 15096

Construction Industry Manufacturers Association
111 East Wisconsin Ave.
Milwaukee, Wisconsin USA 53202

Technical Committee,
Power Crane and Shovel Association

Note: Published in May, 1983; revised April, 1986, and May, 1988.

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REFERENCED MATERIAL*

A. SAE J48, "Guidelines for Fluid Level Indicators"

B. SAE J67 OCT80, "Shovel Dipper, Clam Bucket, and Dragline Bucket Rating"

C. SAE J115 SEP79, "Safety Signs"

D. SAE J153, "Safety Considerations for the Operator"

E. SAE J185 JUN81, "Access Systems for Off-Road Machines"

F. SAE J223 APR80, "Symbols and Color Codes for Maintenance Instructions, Container and Filler Identification"

G. SAE J298, "Universal Symbols for Operator Controls on Industrial Equipment"

H. SAE J695b, "Turning Ability and Off Tracking — Motor Vehicles"

I. SAE J752b, "Maintenance Interval — Construction Equipment"

J. SAE J753 APR80, "Lubrication Chart — Construction and Industrial Machinery"

K. SAE J754a, "Lubricant Types — Construction and Industrial Machinery"

L. SAE J765 OCT80, "Crane Load Stability Test Code"

M. SAE J881 OCT80, "Lifting Crane Sheave and Drum Sizes"

N. SAE J958 MAR81, "Nomenclature and Dimensions for Crane Shovels"

O. SAE J959 OCT80, "Lifting Crane, Wire-Rope Strength Factors"

P. SAE J983 OCT80, "Crane and Cable Excavator Basic Operating Control Arrangements" (Also see "V" below)

Q. SAE J987 OCT80, "Crane Structures — Method of Test"

R. SAE J1063 OCT80, "Cantilevered Boom Crane Structures — Method of Test"

S. SAE J1152 APR80, "Braking Performance — Rubber-tired Construction Machines" (addendum section only)

T. SAE J1234, "Specification Definitions — Off-Road Work Machines"

U. SAE J1349 DEC80, "Engine Power Test Code — Spark Ignition and Diesel"

V. Suggested Mobile Hydraulic Telescoping Crane Basic Operating Control Arrangement (Also see "P" above)

*Documents referenced in this standard are available from CIMA in a separate publication.

SECTION 1

PURPOSE

1.01 This Standard is designed to serve the following purposes:

A. To establish uniform methods and procedures for the guidance of manufacturers, distributors and users in specifying mobile cranes and in presenting data concerning them.

B. To serve as a basis for common understanding, between buyers and sellers, in determining the capabilities and characteristics of machines and in conducting trade negotiations.

C. To promote fair competition.

D. To reaffirm generally recognized and accepted rules of good practice in design, construction, and application of the types of equipment covered herein.

E. To provide means for identification and certification of products which meet the requirements of this standard.

SECTION 2

SCOPE

2.01 MACHINE TYPE

This standard applies to self-propelled mobile cranes, either crawler or wheeled undercarriage, with an upperstructure capable of rotation using a boom and powered wire rope for lifting service as the primary function. Attachments, including clamshell, magnet, dragline, pile driver, or adaptations of the same, as later described herein, may be applied in lieu of the lifting service function.

2.02 UNIFORM SPECIFICATION DATA

This standard provides illustrations, nomenclature and definitions which cover specification requirements pertaining to features of construction, operation, and performance rating. The uniform presentation in manufacturers' literature of the data on the major operating components makes possible convenient and comprehensive comparisons of the characteristics of the crane.

This standard does not cover local or special regulations such as operating on public streets or highways, noise ordinances, electrical codes, etc. Compliance with regulations governing such use is the user's responsibility.

2.03 SAFETY CONSIDERATIONS

This standard contains coverage of considerations pertaining to machine design and construction that are directly related to safety. It is beyond the scope of this standard to cover the entire subject of safety as it relates to the crane manufacturer. Therefore, the safety considerations contained herein should be used as a supplement to other applicable safety codes, insurance requirements, federal, state and local laws, rules and regulations. The safety of the operator and nearby personnel depends upon the operator's care and judgment in the use of the crane. CIMA's "Crane User's Safety Manual," SAE J153, "Safety Considerations for the Operator," and manufacturer's manuals point out important details that should be stressed in operator training.

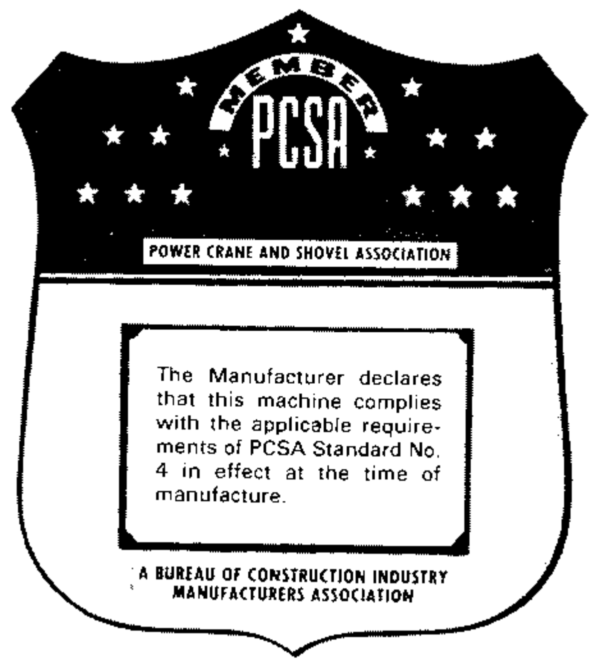

Figure 1. Label Adopted by the Power Crane & Shovel Association

2.04 CERTIFICATION

Manufacturers whose cranes comply with "PCSA Standard No. 4" may so indicate on their products and literature. A suggested manufacturer's certification label is shown in Figure 1.

Although certification is intended only for cranes which fully comply, it is recognized that new developments and practices may comply with the spirit although not the letter of this standard. In such cases, certification and labeling are permissible when variations are clearly stipulated in specifications on contracts and, where applicable, are shown on capacity plates or other signs on the machine. Compliance with this standard is intended only for those cranes bearing the PCSA label manufactured after the publication date of this standard.

SECTION 3

BASIC MOBILE CRANE

The basic mobile crane includes an upperstructure and an undercarriage but does not include the working equipment. (See SAE J958 MAR81, "Nomenclature and Dimensions for Crane Shovels.")

3.01 UPPERSTRUCTURE (REVOLVING)

The upperstructure is the rotating frame and the components located thereon. The upperstructure may include:

3.01.1 Upperstructure Frame

The upperstructure frame is the basic rotating structure to which the working equipment, the counterweight and other components are mounted.

3.01.2 Counterweight

A counterweight is a weight used to supplement the weight of the crane to provide stability for lifting working loads. It is usually attached to the rear of the upperstructure frame.

3.01.3 Enclosure

An enclosure is a structure which may provide environmental protection and styling.

3.01.4 Cab

A cab is an enclosure for the operator and the controls.

3.01.5 Operator's Station

The operator's station is the designated location for the operator when operating the crane.

3.01.6 Swing Mechanism

The swing mechanism is the means of power transmission to rotate the upperstructure. It may consist of a motor, brake or lock, and gear train. The swing motion may be restrained by one of the following:

3.01.6.1 Swing Lock

A swing lock is a mechanical engagement device, not dependent on friction, to hold the upperstructure in one or more fixed positions with respect to the undercarriage. When provided it shall be constructed to prevent unintentional engagement or disengagement.

3.01.6.2 Swing Brake (Parking)

A parking swing brake is a device, such as a friction brake, to restrain the upperstructure in any desired position with respect to the undercarriage. (See Paragraph 6.01.11.)

3.01.6.3 Swing Brake (Dynamic)

A dynamic swing brake is a device to stop, hold or retard the rotating motion of the upperstructure with respect to the undercarriage.

3.01.7 Hydraulic System

The hydraulic system includes one or more pumps, valves, controls, hoses, tubing, motors, cylinders, etc. The hydraulic system converts mechanical power to hydraulic power; transmits, controls and converts hydraulic power back to mechanical force and motion.

3.01.8 Load Hoist Mechanism

The load hoist mechanism is used for lifting, lowering and holding loads or for other purposes, and may consist of a winch, drum or hydraulic cylinder with necessary rope reeving. More than one load hoist mechanism may be provided. The load hoist mechanism when properly maintained and adjusted shall be capable of developing sufficient line pull to control rated loads and be capable of holding that same load in suspended position during operating cycles when reeved according to manufacturer's specifications. The load hoist mechanism shall be provided with a means for holding the brakes in the applied position without the attention of the operator.

3.01.8.1 Load Hoist Drums

A. Drum Ratio — Minimum ratio of lifting crane load hoist drum pitch diameter to nominal rope diameter shall not be less than 18 to 1. (See SAE J881 OCT80.)

B. Rope Capacity — The drums shall have sufficient rope capacity with recommended rope size and reeving to perform machine functions within the range of boom lengths, operating radii and load travel distances stipulated by the manufacturer. Drum flange shall extend a minimum of 12.7 mm (1/2 inch) over top layer of rope.

C. Rope Reserve — No less than two full wraps of rope shall remain on the drums when loads or attachment in extreme positions stipulated by the manufacturer.

D. Adjustments — Brakes and clutches shall be provided with adjustments where necessary to compensate for wear and to ensure proper performance of these components.

3.01.8.2 Load Lowering

Load lowering may be controlled by brakes acting on drums, power load lowering or by other means. The lowering mechanism shall be capable of controlling rated loads.

3.01.8.3 **Load Hoist Line Performance**

A. Available Line Pull — The line pull in kilograms (kg) [pounds (lb)] developed by load hoisting mechanism or off the drum with specified pitch diameter drum or lagging (average pitch diameter of tapered drums), for the first layer of rope, not exceeding that developed by the driving mechanism torque. The manufacturer shall specify the conditions under which the available line pull is developed.

B. Permissible Line Pull — A line pull, less than the available pull, restricted by rope strength, clutch or brake ability, or other limitation in machinery or equipment.

C. Available Line Speed — The line speed in meters per minute (m/min) [feet per minute (ft/min)] at the drum, with specified pitch diameter drum or lagging (average pitch diameter for tapered drum), for the first layer of rope. The manufacturer shall specify the conditions under which the available line speed is developed.

3.01.9 Boom Hoist Mechanism

Defined as the mechanism to control the elevation of the boom and to support the boom. A boom hoist may be a rope drum and its drive or a hydraulic cylinder(s). In a rope supporting and elevating arrangement, boom lowering may be controlled by a brake or by engagement to the power train. The boom hoist mechanism shall be capable of elevating and controlling boom and rated load when adjusted according to manufacturer's specifications. The boom hoist mechanism shall be capable of supporting the boom and rated load without attention from the operator. For a rope supported boom, when used for other than lifting crane service, boom lowering may be controlled by a brake or by engagement to the power train. For hydraulic cylinder supported boom, when used for lifting crane service, boom lowering shall be possible only by release of load check valve by positive pressure from the power source.

3.01.9.1 **Boom Hoist Drums**

A. Drum Ratio — Minimum ratio of boom hoist drum and sheave pitch diameters to nominal rope diameters shall not be less than 15 to 1. (See SAE J881 OCT80.)

B. Rope Capacity — The boom hoist drum or drums shall have sufficient rope capacity to operate the boom to highest angle permitted with recommended rope size and reeving. Drum flange shall extend a minimum of 12.7 mm (1/2 inch) over top layer of rope.

C. Rope Reserves — No less than two full wraps of rope shall remain on the drum or drums with the boom point of crane, clamshell, magnet, dragline and pile driver attachments lowered to the level of the machine supporting surface.

D. Adjustments — Clutches and brakes shall be provided with adjustments where necessary to compensate for wear and to ensure proper performance of these components.

3.01.9.2 A holding mechanism shall be provided for boom support regardless of the type of drive.

A. On rope boom support machines, a ratchet and pawl or other positive locking device shall be provided to prevent unintentional lowering of the boom.

B. For hydraulic cylinder boom support machines, a holding device (such as load checks) shall be provided to prevent uncontrolled lowering of the boom.

3.01.9.3 **Boom Hoisting Time**

Crane boom hoisting and lowering times between minimum and maximum boom angles may be specified without a suspended load.

3.01.10 Gantry

A gantry is used on machines of the rope boom supporting type and is a structure mounted on the revolving upperstructure of the machine to which the boom supporting ropes are attached. Gantries may be available in different heights and types of various conditions.

3.01.11 Boom Telescope Mechanism

Defined as the mechanism to control the extension and retraction of the boom.

3.01.11.1 On a telescoping boom, the retract function shall be capable of controlling rated load. A holding device (such as a load check) shall be provided at the hydraulic cylinder(s).

3.01.11.2 The time to fully extend and fully retract the telescopic boom may be specified without a suspended load. The boom telescoping extension and retraction time shall be measured at a boom angle of 60° from horizontal.

3.02 UNDERCARRIAGE

The undercarriage is an assembly which supports the upperstructure of the crane. It consists of an undercarriage frame, a swing bearing, or hook and load rollers, travel mechanism, and steering mechanism. The undercarriage may be either a crawler or wheeled type.

3.02.1 Crawler Undercarriage

The crawler undercarriage has parallel crawler assemblies.

3.02.1.1 **Crawler Assembly**

A crawler assembly is a track assembly with supporting rollers, drive and idler tumblers or sprocket and idler, track adjusting means and a track frame.

3.02.1.2 **Travel Mechanism**

A travel mechanism is the means of power transmission to the track assemblies to provide propulsion and steering. The travel mechanism includes parking and/or dynamic brakes. (See Paragraph 6.01.11.)

3.02.1.3 Swing Bearing

The swing bearing is the device which allows the upperstructure to rotate about the axis of rotation with respect to the undercarriage, and maintains the radial and axial position of the upperstructure with respect to the undercarriage.

3.02.1.4 Outrigger

An outrigger is a member attached to the undercarriage frame which adjusts to rest on the ground to increase machine stability.

3.02.2 Wheeled Undercarriage

A wheeled undercarriage has powered wheels or axles with wheels.

3.02.2.1 Travel Mechanism

A travel mechanism is the means of power transmission to the wheels to provide propulsion. The travel mechanism includes brakes. Generally, both dynamic and parking brakes are provided. (See Paragraph 6.01.11.)

3.02.2.2 Travel Control

3.02.2.2.1 Single Operator Station

A wheeled undercarriage with a single operator station has the travel controls in either the upperstructure or the undercarriage.

3.02.2.2.2 Separate Operator and Transport Station

A wheeled undercarriage with separate operator and transport station has the main over-the-road travel controls at a transport station on the undercarriage. It has the working equipment controls, and possibly auxiliary travel controls, at an operator station in the upperstructure cab.

3.02.2.3 Wheel and Axle Arrangement

The wheeled undercarriages are classified by two numbers, the first indicating the number of wheels, and the second indicating the number of wheels which are powered. For example:

A. **4** x **4** signifies an undercarriage which has four wheels, all of which are powered for travel.

B. 6 x **4** signifies an undercarriage which has six wheels of which four are powered for travel.

3.02.2.4 Rail-Wheel Attachment

Wheeled undercarriages are sometimes provided with auxiliary retractable, flanged wheels for traveling on railroad type rails.

Generally the rail wheels are positioned so that enough weight remains on the tires, bearing against either rails or ties, to provide traction for both travel and braking.

Compliance with local regulations governing the use of such machines both on public highways and/or public carrier tracks is the user's responsibility.

3.02.2.5 Outrigger

An outrigger is a member attached to the undercarriage frame which adjusts to rest on the ground to increase machine stability.

3.02.2.6 Swing Bearing

The swing bearing is the device which allows the upperstructure to rotate about the axis or rotation with respect to the undercarriage and maintains the radial and axial position of the upperstructure with respect to the undercarriage.

3.02.2.7 Ground Clearance

See SAE J1234.

3.02.3 Hydraulic System

The hydraulic system includes one or more pumps, valves, controls, hoses, tubing, motors, cylinders, etc. The hydraulic system converts mechanical power to hydraulic power; transmits, controls and converts hydraulic power back to mechanical force and motion.

3.03 POWER PLANT

The power plant (or plants) includes the prime power source which may be an internal combustion engine or electric motor, and the power take-off which may be direct drive, friction clutch, fluid coupling, hydrodynamic torque converter, hydrostatic, or an electric generator type, and may or may not include a gear box.

3.03.1 Internal Combustion Engine Power at High Altitude

Since naturally aspirated internal combustion engines tend to lose power as altitude increases, the purchaser should specify the altitude at which the machine is to be used if this exceeds 914.4 m (3,000 feet) above sea level.

3.03.2 The machine manufacturer is not responsible for compliance with local electrical codes, unless such compliance is specified in the contract and copies of the codes are furnished by purchaser.

3.04 POWER TAKE-OFF

Power take-off means from prime-power source may be direct drive, friction clutch, fluid coupling, hydrodynamic torque converter, hydrostatic, or an electric generator type.

3.04.1 Mechanical and Hydrodynamic Drives

Mechanical and hydrodynamic drives shall satisfy one of the following requirements:

A. The power take-off shall include a disconnect clutch controlled from the operator's station.

B. In revolving upperstructure machinery drives, the disconnect clutch shall be provided with a positive manual effort to engage. Where a transmission, having neutral position, is used in combination with an engine clutch, the clutch may be spring loaded.

C. For machines using a hydrodynamic transmission, the means for disconnecting the prime power from the power train may be in the transmission.

SECTION 4

MOBILE CRANE WORKING EQUIPMENT

4.01 LIFTING CRANE

(See SAE J958 MAR81, Figure 6.) Machines with lifting crane attachments are used to raise, lower, move and place loads.

4.01.1 Boom Structure

4.01.1.1 The boom and its suspension system are used to support the working load. It may have a basic structure of one or more sections to which additional sections may be added to increase its length.

The boom is pivotally mounted on the revolving upperstructure and boom angles are adjustable by means described in Section 3.01. The boom may be equipped with boom point sheaves and other parts as required. The boom may be of several different constructions including the following:

A. Lattice booms, wire rope suspended.

B. Cantilevered booms, fixed or telescoping.

C. Tower attachment.

4.01.1.2 Boom Length

(See "X" in SAE J958 MAR81, Figure 6.) Boom length is the straight line through the centerline of boom pivot pin to the centerline of the boom point load hoist sheave pin, measured along the longitudinal axis of the boom.

4.01.1.3 Boom Angle

(See "Z" in SAE J958 MAR81, Figure 6.) Boom angle above horizontal of the longitudinal axis of the boom.

4.01.1.4 Boom Hoist Ropes

(For the rope boom supporting type.)

A. Continuous Suspension — Boom hoist running rope reeving leads without interruption from the gantry to the boom head. If the boom is lengthened or shortened by a considerable amount, it may be necessary to reeve a longer or shorter rope.

B. Pendant Suspension — A floating boom harness, bridle, or spreader equipped with sheaves is connected to the boom upper section by stationary ropes usually called pendants. The boom hoist running rope leads from the gantry to the floating boom harness. To change the boom length, it is necessary only to change the pendants.

C. Mast Suspension — Similar to Pendant Suspension except that the floating boom harness is supported by a strut hinged near the boom pivot.

4.01.1.5 Boom Angle Indicator

An indicator showing the angle of the boom above horizontal shall be located on the crane to be clearly visible to the operator from his position at the controls.

4.01.1.6 Boom Length Indicator

Telescopic booms that have an indicator shall show the boom length from minimum to maximum and be visible to the operator from his position at the controls.

4.01.1.7 Boom Stops

Stops shall be provided to resist the boom falling backwards on a grade, in a high wind, or upon sudden release of load.

A. A fixed or telescoping bumper.

B. A shock absorbing bumper.

C. Hydraulic boom elevation cylinder(s).

4.01.1.8 Boom Hoist Limiter

A boom hoist limiter or shutoff should be provided to automatically stop the boom hoist when the boom reaches a predetermined high angle.

4.01.1.9 Load Hooks

Load hooks and load blocks shall be weighted to overhaul the hoist rope from the highest hook position for boom or boom and jib length and number of parts of hoist rope, using manufacturer's recommended reeving for the loads to be lifted. All load block hooks and ball assemblies shall be equipped with latches and permanently labeled with their rated capacity and weight. Latches are intended only to retain loose rigging. The latch is not a load supporting device.

4.01.1.10 Jib or Boom Tip Extension

(See "19" in SAE J958 MAR81, Figure 6.) An extension attached to the boom head to provide added boom length for handling specified loads. The jib may be in line with boom or hoist.

Jibs or boom tip extensions which can pivot in operation shall be equipped with stops to resist falling backwards.

4.01.2 Rated Loads

(See Paragraph 6.02.1.) Lifting crane rated loads at specified radii shall not exceed the following percentages of tipping load (Paragraph 6.01.13) at specified radius:

(a) Crawler Machines	75%
(b) Wheeled Machines	75%
(c) Machines on Outriggers	85%

Rated loads shall be based on the direction of minimum stability, unless otherwise specified.

4.01.3 Allowable Rope Loading

The strength factors for wire ropes shall not be less than those specified in SAE J959 OCT80.

	Running	Standing
Supporting Rated Load	3.5	3.0
Supporting Boom and Attachments at Gantry Height to Minimize Travel Clearance	3.5	3.0
Supporting Boom at Ground Level for Erection	3.0	2.5

Rotation resistant rope shall have a strength factor of not less than 5.

The rope strength factor shall be considered to be total "nominal" breaking strength of all ropes in the system divided by the load imposed on the rope system when supporting the static weights of structure and crane rated load (Paragraph 4.01.2).

4.01.4 Sheave Diameters

Ratios of sheave pitch diameter to nominal rope diameter shall not be less than those specified in SAE Standard J881 OCT80.

Minimum Ratio	Sheave Pitch Diameter To Rope Diameter
Load hoisting sheaves on boom	18.0 to 1
Load hoisting sheaves in lower block	16.0 to 1
Boom hoisting sheaves	15.0 to 1

4.01.5 Drum Diameters

For drum to rope diameter ratios, see 3.01.8.1(A) and 3.01.9.1(A).

4.01.6 Crane Rating Chart

A load rating chart and/or label(s) shall be located on the crane to be available to the operator from his position at the controls. It shall include:

Rated crane loads for recommended boom lengths at recommended radii.

Basis of crane rating: firm, level, and uniform supporting surface, outrigger position(s), rating percentage (Paragraph 4.01.2); practical working load definitions (Paragraph 6.02.2). Rated loads based on factors other than stability shall be so indicated.

Maximum loads in relation to recommended rope size and strength and number of parts in hoist tackle (see Paragraph 4.01.3).

Allowances to be made to rated loads on the boom when attachments such as jibs are mounted.

Data on jibs: Available lengths, permissible offsets and rated loads.

4.02 CLAMSHELL

4.02.1 Clamshell Equipment

(See "21" in Figure 6, SAE J958 MAR81.) Machines with clamshell attachments are used to load material from stockpiles, gondola cars, barges, and the like, or from virgin soil generally out of small area holes, deep trenches, or from below water. Orange peel buckets, grapples, and similar rope suspended attachments are included in this classification.

4.02.1.1 Clamshell Bucket

A clamshell bucket can be operated either by ropes or hydraulic cylinders.

A. A rope operated bucket usually consists of two or more similar scoops hinged together and a head assembly connected to the outer corners of the scoops by struts. When the head and hinge are pulled toward each other, the scoops are forced together to dig and hold material. Control is by a holding line reeved over a boom point sheave and attached to the head assembly to support the bucket in open position and usually by a closing line also reeved over a boom point sheave, ending in a force amplifying tackle or other means between the head assembly and scoop hinge to close the bucket.

B. A hydraulic clamshell bucket usually consists of two or more scoops hinged to a head assembly housing the hydraulic cylinder or cylinders and the force amplifying linkage to open and close the scoops and to supply the digging force for the scoops. The bucket assembly is suspended from the boom by a rope. Because digging ability is largely dependent upon bucket weight, buckets are supplied in various weight classes which range from light for easily dug stockpiled materials to heavy for excavating a hard pan material and the like.

4.02.1.2 Boom

See Paragraph 4.01.1.

4.02.1.3 Boom Angle Indicator

See Paragraph 4.01.1.5.

4.02.1.4 Tagline

A wire rope attached to the bucket and a spring loaded, counterweighted, or powered unit keeping it in tension to retard rotation and pendulum swaying of the otherwise freely suspended bucket.

4.02.2 Clamshell Rating

Shall be the lesser value as determined by Paragraphs 4.02.2.1, 4.02.2.2 or 4.02.2.3.

4.02.2.1 Rated Loads

(See Paragraph 6.02.1.) The combined weight of the clamshell bucket and contents shall not exceed 90% of the Crane Rated Load at specified radius.

4.02.2.2 Maximum Clamshell Load

The combined weight of bucket and contents shall not exceed the limits imposed by allowable rope loading (Paragraph 4.02.3).

A. Mechanical Drive Machines — For normal operation, the combined weight of bucket and contents should not exceed 70% of the available closing line pull [Paragraphs 3.01.8.3(A) and 5.03.4].

B. Multi Prime Power Source and/or Other Type Drive Machines — For normal operation, the combined weight of bucket and contents should not exceed the permissible closing line pull [Paragraph 3.01.8.3(B)].

4.02.2.3 The manufacturer should state any other limitations on bucket size that apply to particular machines, and when requested, to particular operations.

4.02.3 Allowable Rope Loading

The rope strength factor shall be considered to be the total "nominal" breaking strength of all ropes in the system divided by the load imposed on the rope system when supporting the static weights of structure and clamshell bucket loaded to rated capacity. See Paragraph 4.01.3 for allowable rope loading.

In a rope operated bucket, the holding line cannot be included as support for a loaded bucket.

4.02.4 Sheave Diameters

Ratios of sheave pitch diameter to nominal rope diameter shall not be less than those specified in SAE J881 OCT80.

Minimum Ratio	Sheave Pitch Diameter To Rope Diameter
Load hoisting sheaves on boom	18.0 to 1
Closing tackle sheave in bucket	16.0 to 1
Boom hoisting sheaves	15.0 to 1

4.02.5 Clamshell Rating Chart

A load rating chart shall be located on the machine available to the operator from his position at the controls. It shall include:

Rated clamshell loads for recommended boom lengths at recommended radii.

Basis for clamshell rating; firm, level, and uniform supporting surface; rating percentage (Paragraph 4.02.2) and practical working load definitions (Paragraph 6.02.2).

Maximum weight of clamshell bucket and contents (Paragraph 4.02.2).

Notes on the crane rating chart may be used in lieu of a separate chart.

4.02.6 Clamshell Bucket Capacity Rating

See SAE J67 OCT80.

4.03 MAGNET

4.03.1 Magnet Equipment

(See "24" in Figure 6, SAE J958 MAR81.) Machines with magnet attachments are used to handle ferrous products in either the form of raw materials as pig iron and scrap, or as semi-finished billets, plates and castings.

4.03.1.1 An electromagnet is suspended from the crane hook, powered from a generator, and regulated at the operator's station.

4.03.1.2 Boom — See Paragraph 4.01.1.

4.03.1.3 Boom Angle Indicator — See Paragraph 4.01.1.5.

4.03.1.4 Magnet Generator — Used to produce current to energize the electromagnet.

4.03.2 Magnet Load Rating

Shall be the lesser value as determined by Paragraphs 4.03.2.1, 4.03.2.2, or 4.03.2.3.

4.03.2.1 Rated Loads

(See Paragraph 6.02.1.) For normal operation the combined weight of magnet and load for any given radius of operation shall not exceed 90% of Crane Rated Load.

4.03.2.2 Maximum Magnet Load

The combined weight of magnet and load shall not exceed the limits imposed by allowable rope loading (Paragraph 4.02.3).

A. Mechanical Drive Machines — For normal operation, the combined weight of magnet and load should not exceed 70% of the available hoist line pull [Paragraphs 3.01.8.3(A) and 5.03.4].

B. Multi Prime Power Source and/or Other Type Drive Machines — For normal operation, the combined weight of magnet and load should not exceed the permissible line pull [Paragraph 3.01.8.3(B)].

4.03.2.3 The manufacturer should state any other limitation which may apply to a particular machine or operation.

4.03.3 Allowable Rope Loading

See Paragraph 4.01.3.

4.03.4 Sheave Diameters

See Paragraph 4.01.4.

4.03.5 Magnet Rating Chart

A load rating chart shall be located on the machine available to the operator from his position at the controls. It shall include:

Rated magnet loads for recommended boom lengths at recommended radii.

Basis of magnet rating: firm, level, and uniform supporting surface; rating percentage (Paragraph 4.03.2); and practical working load definitions (Paragraph 6.02.2).

Maximum weight of magnet and load (Paragraph 4.03.2).

Notes on the crane rating chart may be used in lieu of a separate chart.

4.04 DRAGLINE

4.04.1 Dragline Equipment

(See "22" in Figure 6, SAE J958 MAR81.) Machines with dragline attachments are generally used to excavate material from below the grade on which the machine is placed.

4.04.1.1 A dragline bucket is loaded by the drag rope pulling it toward the machine, is lifted and carried by the hoist rope reeved over the boom point sheave, and is balanced by the dump rope interconnecting the drag and hoist ropes. Buckets are supplied in various weight classes ranging from light for loose formations to heavy for compact to cemented formations.

4.04.1.2 Boom — see Paragraph 4.01.1.

4.04.1.3 Fairlead — A device to guide wire rope for proper spooling.

4.04.2 Dragline Load Rating

Shall be the lesser value as determined by Paragraphs 4.04.2.1, 4.04.2.2 or 4.04.2.3.

4.04.2.1 Rated Loads

(See Paragraph 6.02.1.) The combined weight of dragline bucket and contents shall not exceed 100% of Crane Rated Load.

4.04.2.2 Maximum Dragline Load

The combined weight of bucket and contents shall not exceed the limits imposed by allowable rope loading (Paragraph 4.02.3).

A. Mechanical Drive Machines — For normal operation, the combined weight of bucket and contents should not exceed 70% of the available hoist line pull. [Paragraphs 3.01.8.3(A) and 5.03.4.]

B. Multi Prime Power Source and/or Other Type Drive Machines — For normal operation, the combined weight of bucket and contents should not exceed the permissible hoist line pull [Paragraph 3.01.8.3(B)].

4.04.2.3 The manufacturer should state any other limitations on bucket size that apply to particular machines and, when requested, to particular operations.

4.04.3 Dragline Rating Chart

A load rating chart shall be located on the machine, available to the operator from his position at the controls. It shall include:

Rated dragline loads for recommended boom lengths at recommended radii.

Basis of dragline rating: firm, level and uniform supporting surface; rating percentage (Paragraph 4.04.2); and practical working load definitions (Paragraph 6.02.2).

Maximum weight of dragline bucket and contents (Paragraph 4.04.2).

Notes on the crane rating chart may be used in lieu of a separate chart.

4.04.4 Dragline Bucket Capacity Rating

See SAE J67 OCT80.

4.05 PILE DRIVER

4.05.1 Pile Driver Equipment

(See "23" Figure 6, SAE J983 OCT80.) Machines with pile driver attachments are used to drive or extract piling.

4.05.1.1 Pile Drive Units

These units include the following:

A. Drop Hammer — A simple weight sliding in leads, which is raised by the hoist machinery and allowed to drop on the upper end of the pile. It can be used to drive both vertical (plumb) and off-vertical (batter) piling.

B. Power Hammer — A unit, usually guided by leads, that rests on the upper end of the pile and which contains within itself a member (ram) which is caused to reciprocate either by means of externally supplied air, steam, hydraulic fluid under pressure, or by internal combustion within the unit. It can be used to drive both plumb and batter piling.

C. Vibrator — A unit which normally is firmly clamped or fixed to the upper end of the pile and which contains elements that produce vibratory forces, usually longitudinal, in the pile. The weight of the unit, in some cases supplemented by counterweight or other downward forces, when added to the vibratory forces, drives the pile. It can be used to drive both plumb and batter piling.

4.05.1.2 Extractors

These units include the following:

A. Pulling frame — A mechanism which amplifies hoisting forces to permit direct extraction of piling.

B. Power extractor — A unit hanging from the hoist line or block and attached to the upper end of the pile and containing within itself a member (ram) which is caused to reciprocate either by means of an externally supplied air, steam, hydraulic fluid under pressure, or by internal combustion within the unit. Upward pull from the hoisting machinery supplements the extraction forces.

C. Vibrator — Same as described in 4.05.1.1 except that upward forces in excess of the weight of the unit are added by means of the hoist machinery in order to extract the pile.

NOTE: When power or vibratory extractors are employed, high hoisting forces are usually required, and a shock absorber or vibration isolator interposed between the hoist line and the extractor is recommended to reduce the shock and vibration transmitted to the boom and machine.

4.05.1.3 Boom

See Paragraph 4.01.1.

4.05.1.4 Pile Leads

These units include the following:

A. Box or Parallel — A structure consisting of two parallel, properly shaped members suitably interconnected which form a guide within or on which the pile driving unit and pile cap may operate.

B. Spud — A structure consisting of a single suitably shaped member on which the pile driving unit and pile cap, when equipped with suitable guides, may operate.

4.05.1.5 Pile Lead Attachment

The pile leads may be attached to the basic machine crane boom in several ways including:

A. Free Swinging — Where the leads are suspended by one of the hoist cables.

B. Underhung or Fixed — Where the upper ends of the leads are hinged directly at or near the boom point. Struts may be provided to tie the lower end into the machine.

C. Extended or Cantilevered — Where leads are attached similarly to the underhung method except that in addition to the lead hanging below the boom point, it extends upward for some distance above the boom point as well. This construction permits the driving of piling in lengths in excess of the boom length.

4.05.1.6 Pile Cap

An adapter between the pile driving unit and the upper end of the pile used to center the pile under the pile driving unit and to reduce damage to the upper end of the pile.

4.05.1.7 Cushion Block

A means of reducing impact damage to hammer and pile. This unit usually consists of plastic or wood cushioning material suitably retained and positioned between pile driving hammer and pile cap. Use of wire rope, steel plates, or other such inelastic material as cushioning means is not normally advisable.

4.05.1.8 Extra Drums

Machines equipped with pile driving attachments may be equipped with more than two hoisting drums to meet the various needs of this operation.

4.05.2 Load Capacity

4.05.2.1 When driving plumb piling, the combined weights of leads, pile driving unit, pile, and any attached appurtenances should not exceed the rated lifting capacity of the machine with the boom length used at the operating radius. If piling is to be driven at a fore and aft batter (off-vertical but lying in a vertical plane passing through the longitudinal centerline of machine and boom), necessary allowances for the changes in radii of centers of gravity of leads, pile driving unit, and pile must be made to avoid exceeding the rated lifting capacity. Great care must be exercised for side-batter (pile inclined out of a vertical plane passing through the longitudinal centerline of machine and boom) as such operation imposes severe demands upon both strength and stability of machines so employed.

4.05.2.2 When extracting piling, the combined weight of the extractor plus piling plus piling-resistance should not exceed 70% of the crane rated load or 70% of the rated line pull.

4.05.2.3 The manufacturer should state any other limitation which may apply to a particular machine or operation.

SECTION 5

SPECIFICATIONS AND DATA

5.01 UPPERSTRUCTURE

5.01.1 Swing Speed

Manufacturer should specify speed attainable on level ground, rpm.

5.01.2 Swing Lock or Swing Brake

A swing lock or swing brake shall be provided. The manufacturer shall specify the type furnished. (Refer to 3.01.6.1, 3.01.6.2, and 3.01.6.3.)

5.01.3 Load Hoist Mechanism

Manufacturer shall specify:

A. Available line pull [Refer to 3.01.8.3(A)].

B. Permissible line pull [Refer to 3.01.8.3(B)].

C. Available line speed [Refer to 3.01.8.3(C)].

5.01.4 Gantry

Manufacturer shall specify:

A. Condition of use.

B. Whether fixed or lowerable.

5.01.5 Dimensions

Manufacturer shall specify:

Upperstructure dimension (see SAE J958 MAR81).

5.02 UNDERCARRIAGE

5.02.1 Crawler Undercarriage

5.02.1.1 Gradeability

Manufacturer shall specify gradeability for crane without load in percent of grade that allows satisfactory travel, and identify the limiting factor(s) such as engine lubrication, drawbar pull, traction, steering, or braking ability, etc.

5.02.1.2 Speed

Manufacturer shall specify travel speed (or speeds if more than one is available) attainable under specified conditions, km/h (mph).

5.02.1.3 Steering

Crane shall be capable of being steered right and left in both directions of travel. Counter rotation ability should be specified.

5.02.1.4 Brakes

Locks or brakes shall be provided capable of preventing track assembly rotation, without travel power applied, on any grade the crane is capable of climbing. Brakes are not intended to prevent skidding. Manufacturer shall specify the type of holding means provided.

5.02.1.5 Crawler Dimensions

Dimensions specified by the manufacturer shall be as shown in SAE J958 MAR81.

5.02.1.6 Bearing Length and Area

The effective bearing length of each crawler assembly on the ground is computed as the nominal center to center length, J_2, plus 35% of (J_4 minus J_2). The total crawler assembly bearing area is computed by multiplying the effective crawler assembly bearing length (as above defined) of both crawler assemblies by the width of the track shoe. See Figure 2.

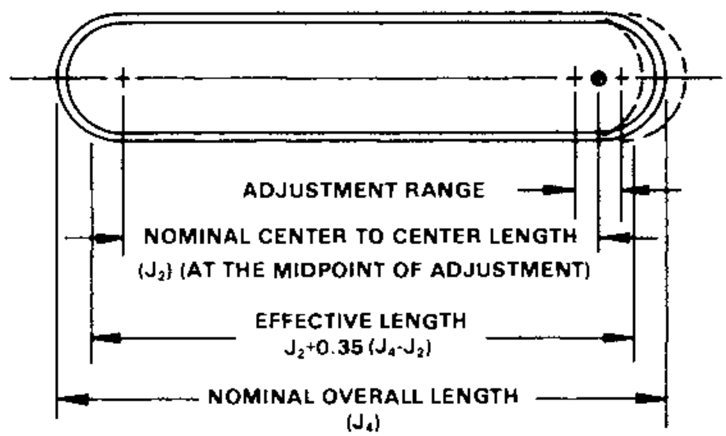

Figure 2.

5.02.1.7 Ground Pressure

Ground pressure shall be specified and is the average pressure in kPa (psi) derived by dividing the total working weight of the machine but without load, by the crawler assembly bearing area. Machine configuration shall be specified.

5.02.2 Wheeled Undercarriage

5.02.2.1 Separate Engine

When the undercarriage has a separate engine, the power plant shall be specified according to Section 5.03.

5.02.2.2 Gradeability

Manufacturer shall specify gradeability for machine without load in percent of grade that allows satisfactory travel, and identify the limiting factor(s) such as engine lubrication, drawbar pull, traction, steering, or braking ability, etc.

5.02.2.3 Speed

Manufacturer shall specify travel speed (or speeds if more than one is available) attainable under specified conditions, km/h (mph).

5.02.2.4 Steering

Manufacturer shall specify the "Turning Diameter — Wall to Wall," m (ft), and "Turning Diameter," m (ft) for each mode of steering (see SAE J695b, "Turning Ability and Off Tracking — Motor Vehicles"). Machine shall be capable of being steered right and left in both directions of travel. Describe auxiliary steering system if used.

5.02.2.5 Brakes

Brakes shall be provided to meet applicable regulations. Also see SAE J1152 APR80, "Braking Performance-Rubber-Tired Construction Machines." In addition, locks or brakes shall be provided capable of preventing wheel rotation, without travel power applied, on any grade the machine is capable of climbing. Brakes are not intended to prevent skidding. Manufacturer shall specify the type of holding means provided.

5.02.2.6 Wheeled Crane Dimensions

Dimensions shown by the manufacturer shall be as shown in SAE J958 MAR81.

5.02.2.7 Remote Control

Undercarriage functions controlled from the upperstructure shall be specified.

5.02.2.8 Outriggers

Manufacturer shall specify:

A. Number and location of outriggers.

B. Whether outriggers are fixed or extendable; if extendable, whether telescoping or hinged, and whether operated manually or by power.

C. Whether jacks and supporting floats are furnished; if furnished, whether jacks are manual or powered. If locks are furnished, type of lock shall be specified.

D. Whether outrigger boxes are permanently attached or removable.

E. Whether outriggers are separately controlled.

5.03 POWER PLANT

5.03.1 Internal Combustion Engine Data

Manufacturer shall specify:

A. Engine make and model number.

B. Spark ignition or diesel.

C. Number of cylinders, bore and stroke, mm (in), displacement, cm^3 (in^3), and two or four cycle.

D. Naturally aspirated, blown, supercharged, or turbocharged. Special characteristics, such as after-cooling, if employed.

E. Liquid or air cooled.

F. Type of starting equipment and voltage if applicable.

G. Type of generating equipment including voltage and amperage.

H. Rated engine speed, rpm.

I. Gross engine power, kW (hp), and net engine power, kW (hp), rated speed, (rpm). (See SAE J1349 DEC80, "Engine Power Test Code — Spark Ignition and Diesel.")

J. Fuel tank capacity, L (gal).

K. Altitude limitations, m (ft).

L. Cooling system refill capacity, L (gal).

M. Lubricating oil refill capacity, L (qt).

N. Slope operation limitations, percent of grade.

5.03.2 Electric Motor Data

Manufacturer shall specify:

A. Alternating or direct current, voltage, and frequency, Hz.

B. Type of motor.

C. Motor rating (continuous, or intermittent time), kW (hp), at rated speed, rpm.

D. Type of starter.

5.03.3 Pumps

Manufacturer shall specify for each main pump:

A. Type.

B. Engine to pump speed ratio.

C. Flow, L/min (gpm), at specified pressure, kPa (psi), and speed, rpm.

D. Maximum working pressure, kPa (psi).

5.03.4 Mechanical and Hydrodynamic Drives

Net delivered horsepower and speed at the power take-off shaft shall be specified. Machine performance specifications shall be based on this power.

Hydrostatic Drives

Net delivered horsepower and speed at the flywheel shall be specified. For hydraulic functions, performance specifications shall be based on the pump's net gallonage at specified pressure and recommended oil operating temperature.

5.04 WORKING EQUIPMENT

5.04.1 Lifting Crane Data

The manufacturer shall publish the following data:

5.04.1.1 Data on load rating chart (see Paragraph 4.01.6).

5.04.1.2 Telescopic boom information (if applicable):

A. List the maximum telescopic travel length of each boom telescopic section.

B. Specify whether sections are telescoped with power or manual.

C. Procedure for extending and retracting telescopic boom section.

5.04.1.3 Height of boom point load hoist sheave pin for permissible boom configurations and operating ranges.

5.04.1.4 For each hoist drum or hoist mechanism:

A. Drum Pitch Diameter.

B. Available Line Pull [see Paragraph 3.01.8.3(A)].

C. Permissible Line Pull [see Paragraph 3.01.8.3(B)].

D. Available Line Speed [see Paragraph 3.01.8.3(C)].

E. Rope Spooling Capacity [see Paragraph 3.01.8.1 (B)].

5.04.1.5 Hoist holding mechanism:

State whether hoist holding mechanism is automatically controlled, manually controlled, if free fall available, or any combination thereof.

5.04.1.6 Hydraulic relief valve (if applicable):

Relief valve settings shall be specified and any change in relief valve setting without the consent of the manufacturer shall be the user's responsibility.

5.04.1.7 Tire Pressures

5.04.2 Clamshell Data

The manufacturer shall publish the following data:

5.04.2.1 Data on clamshell rating chart (see Paragraph 4.02.5).

5.04.2.2 For holding and closing drums:

A. Drum Pitch Diameter.

B. Available Line Pull [see Paragraph 3.01.8.3(A)].

C. Permissible Line Pull [see Paragraph 3.01.8.3(B)].

D. Available Line Speed [see Paragraph 3.01.8.3(C)].

5.04.2.3 For hoisting mechanisms for hydraulic operated clamshell:

A. Drum Pitch Diameter.

B. Available Line Pull [see Paragraph 3.01.8.3(A)].

C. Permissible Line Pull [see Paragraph 3.01.8.3(B)].

D. Available Line Speed [see Paragraph 3.01.8.3(C)].

5.04.2.4 For opening and closing mechanism for hydraulic operated clamshell:

A. Hydraulic Flow, L/min (gpm).

B. Hydraulic Pressure, kPa (psi).

5.04.3 Magnet Data

The manufacturer shall furnish the following data:

5.04.3.1 Data on magnet rating chart (see Paragraph 4.03.5).

5.04.3.2 For hoist drum:

A. Drum Pitch Diameter.

B. Available Line Pull [see Paragraphs 3.01.B.3(A) and 5.03.4].

C. Permissible Line Pull [see Paragraphs 3.01.B.3(B) and 5.03.4].

D. Available Line Speed [see Paragraphs 3.01.8.3(C) and 5.03.4].

5.04.3.3 For magnet generator:

A. Driven by main engine or separate engine.

B. AC or DC.

C. Voltage.

D. KW Rating.

5.04.4 Dragline Data

The manufacturer shall furnish the following data:

5.04.4.1 Data on dragline rating chart (see Paragraph 4.04.3).

5.04.4.2 For hoist and drag drums:

A. Drum Pitch Diameter.

B. Available Line Pull [see Paragraphs 3.01.8.3(A) and 5.03.4].

C. Available Line Speed [see Paragraphs 3.01.8.3(C) and 5.03.4].

SECTION 6

MOBILE CRANE CONSTRUCTION AND CHARACTERISTICS

Mobile cranes may be subjected to a wide variety of job applications and environmental conditions. This section pertains to the physical capability and construction features of the crane in relation to performance of specific work intended under conditions expressly described by the manufacturer's publications. Many construction characteristics and features of the crane design are covered elsewhere in this standard. For additional information on the proper use of mobile cranes see CIMA's "Crane User's Safety Manual," the manufacturers' manuals, the crane load rating chart and SAE J153, "Safety Considerations for the Operator."

6.01 CRANE DESIGN REQUIREMENTS

The following requirements in Section 6.01 are the responsibility of the crane manufacturer.

6.01.1 Hydraulic Pressure Limiting Device

Hydraulic relief valves or other devices used to limit pressure within the hydraulic system shall have pressure settings of sufficient magnitude to provide the capabilities of operation described in previous sections. Gauge ports shall be provided in each hydraulic circuit for checking the manufacturer's specified setting.

6.01.2 Clutches and Brakes

Clutches and brakes shall be provided with adjustments where necessary to compensate for wear and to maintain proper performance of these components.

6.01.3 Cab Construction

Insofar as practical, without interference with operation, cabs shall provide protection for the operator from the weather. Cab windows and/or openings shall be provided and arranged for good visibility of the work area. Visibility of other areas should be provided as extensively as crane component arrangement and enclosures will permit. All operator station windows shall be of shatter-resistant glazing. Equivalent glazing materials may be used unless prohibited by other regulations.

Provisions should be made in the cab for storage of operator's manuals and any other manufacturer information or instructions.

Mounting provisions should be made for storage of a fire extinguisher in the operator's station(s).

6.01.4 Access to the Cab or Enclosure

For steps, ladders, and grab handles used for entering and exiting the cab or enclosure for servicing or operating, the crane should comply with SAE J185 JUN81, "Access Systems for Off-Road Machines."

6.01.5 Doors and Windows

All doors and windows whether of the sliding or swinging type shall be adequately restrained from accidental opening or closing. The cab door shall either swing outward or slide rearward to open.

6.01.6 Catwalks, Walkways, and Steps

All walkways and steps should comply with SAE J185 JUN81, "Access Systems for Off-Road Machines." Principal walking surfaces shall be of a skid resistant type.

6.01.7 Engine Exhaust

Engine exhaust gases shall be piped to the outside of the enclosure and directed away from the operator.

6.01.8 Guards and Warnings

Suitable guards shall be provided to protect operators or maintenance personnel during their normal duties, from exposure to known hazards that are inherent characteristics on the machine (such as rotating machinery parts). If a guard is impractical, it is the responsibility of the manufacturer to warn by means of an appropriate sign. This sign should be designed and installed in accordance with SAE J115 SEP79, "Safety Signs," consistent with physical limitations on size and location.

Rope carrying sheaves, which can momentarily be unloaded, shall be provided with close-fitting guards to guide the rope in the groove when the load is reapplied.

6.01.9 Lubrication and Fluid Fills

Lubrication fittings and fluid fill points (fuel, coolant, hydraulic fluid, etc.) should be located in areas that are easily accessible and will not collect fluid spills.

Fluid level indicators should follow the guidelines set forth in SAE J48, "Guidelines for Fluid Level Indicators." Lubrication charts shall be furnished by the manufacturer. The preferred format of the lubrication chart is shown in SAE J753 APR80, "Lubrication Chart — Construction and Industrial Machinery."

Preferred maintenance intervals are covered in SAE J752b, "Maintenance Interval — Construction Equipment." Lubricant types used in lubrication charts are shown in SAE J754a, "Lubricant Types — Construction and Industrial Machinery." For preferred symbols and color codes for fluid fills, see SAE J223 APR80, "Symbols and Color Codes for Maintenance Instructions, Container and Filler Identifications."

6.01.10 Controls

Controls may be located on the upperstructure and/or the undercarriage. All controls essential to operation shall be located within easy reach of the operator when at the operator's station(s). The placement of controls shall allow for proper coordination of hand and foot movement required by the various types of working equipment. See SAE J983 OCT80, "Crane and Cable Excavator Basic Operating Control Arrangement" and Reference V, "Suggested Mobile Hydraulic Crane Basic Operating Control Arrangement."

6.01.10.1 Hand Levers and/or Foot Pedals

Controls for load hoist, boom hoist, swing, and boom telescope, shall return to neutral position automatically upon operator release when not intentionally restrained for functional purposes.

The function of all controls as specified in SAE J983 OCT80 and/or Reference V shall be clearly identified. Indentification should be labels or diagrams as described in SAE J983 OCT80, SAE J298, or Reference V.

6.01.10.2 Control Forces and Movements

When controls and corresponding controlled elements are properly maintained and adjusted and the machine is operated within the manufacturer's rating with recommended mechanisms, the following shall be provided under normal operation.

A. Control forces not greater than 15.9 kg (35 lb) on hand levers. Forces not greater than 22.7 kg (50 lb) on foot pedals.

B. Travel distance on hand levers not greater than 35.56 cm (14 inches) from neutral position on two-way levers and not greater than 60.96 cm (24 inches) on one-way levers. Travel distance on foot pedals not greater than 25.4 cm (10 inches).

6.01.11 Brakes, Parking

Parking brakes, such as travel and swing, shall be of a design that can be set in the holding position and remain so without operator attention.

6.01.12 Electric Motors

Electric powered machines shall be adequately grounded between the upperstructure and the mounting base to avoid damage to anti-friction bearings.

6.01.13 Tipping Conditions

A machine is considered to be at the point of tipping when a balance is reached between the overturning moment and the stabilizing moment of the machine.

Note: For suggested test procedure see SAE Recommended Practice. J765 OCT80.

6.01.13.1 When outriggers are used, wheels or crawler tracks shall be relieved of all weight by the outrigger jacks or blocking, unless otherwise specified by the manufacturer.

6.01.13.2 Radius of load (see "Y" in SAE J958 MAR81, Figure 6) is the horizontal distance from a projection of the axis of rotation to the supporting surface, before loading, to the center of vertical hoist line with load applied.

6.01.13.3 Tipping load is the load producing a tipping condition at a specified radius. Weights of hook, hook blocks, slings, and other load handling devices shall be considered part of the load to be handled. When more than a minimum required hoist reeving is used, the additional rope weight shall be considered part of the load to be handled.

6.01.14 Backward Stability With Boom Structure Installed

The backward stability of a crane is its ability to resist overturning in the direction opposite to boom point while in the unloaded condition. The resistance to backward overturning is reflected in the margin of backward stability.

The general conditions for determination of the backward stability margin, applicable to all cranes within the scope of this section, are as follows:

A. Crane to be equipped for crane operation with shortest recommended boom positioned at its maximum recommended boom angle for that boom length;

B. Crane to be unloaded (lower load block on support);

C. Outriggers free of the bearing surface;

D. Crane to be standing on a firm supporting surface level within 1% grade;

E. All fuel tanks to be at least half full, and all other fluid levels as specified.

6.01.14.1 Minimum Backward Stability Conditions

The following are minimum acceptable backward stability conditions:

A. **Crawler Cranes**

(1) The total load on the tipping fulcrum on the side or end of the undercarriage supporting the least load shall not be less than 15% of the total weight of the crane.

(2) When applied to crawler cranes equipped with retractable crawler assemblies, the manufacturer must provide cautionary information on the crane visible to the operator if the criterion described in 6.01.14.1 A(1) is not met when crawlers are retracted.

B. **Wheel-Mounted Cranes** (on tires or on wheels)

(1) With the longitudinal axis of the rotating superstructure of the crane at 90 degrees to the longitudinal axis of the carrier, but total load on all wheels on the side of the carrier under the boom shall not be less than 15% of the total weight of the crane.

(2) With the longitudinal axis of the rotating superstructure of the crane in line with the longitudinal axis of the carrier in either direction, the total load on all wheels under the lighter loaded end of the carrier shall not be less than 15% of the total weight of the crane in the manufacturer's specified work area, and not less than 10% of the total weight of the crane in the area not specified as a work area.

(3) The on-tire or on-wheels limitations must be met unless cautionary information is placed on the crane, visible to the operator. This information shall state the operating conditions that require the outriggers to be set to maintain sufficient backward stability.

C. **Wheel-Mounted Cranes** (on outriggers)
Under the conditions of 6.01.14 A, B, C, D and E, and with the machine supported level on fully extended outriggers with all tires free of the supporting surface, the resistance to overturning in a backward direction shall be equivalent to those conditions specified in B(1) and (2) above.

6.01.15 Backward Stability With Boom Structure Removed

The manufacturer must provide cautionary information if the criterion described in 6.01.15.1 is exceeded with conditions as in 6.01.14 but with the boom structure removed from the crane. This cautionary information shall be placed on the crane, visible to the operator. This information shall also caution if the counterweight must be either removed or securely supported from the surface upon which the crane stands before the working equipment may be removed.

6.01.15.1 The total load on all wheels, outriggers, crawler track or idlers (tipping fulcrum) on the side or end of the undercarriage supporting the least load shall not be less than 5% of the total weight of the crane.

6.01.16 Forward Stability

Cranes may not have sufficient forward stability (in the direction of the boom) to handle some boom lengths. Information shall be provided on the load or load radius rating chart stating any limitations in boom length, angle for specified operating conditions of outriggers, direction of boom, or other requirements.

6.02 LOAD DEFINITIONS

6.02.1 Rated Load

Rated loads at specified radii are the lesser of a specified percentage of tipping loads or the machine's hydraulic or structural competence as established by the manufacturer's rating charts and are maximum loads at those radii covered by the manufacturer's warranty. Weight of hook, hook blocks, slings and other load handling devices shall be considered part of the load to be handled. When more than the minimum required hoist reeving is used, the additional rope weight shall be considered part of the load to be handled.

6.02.2 Practical Working Loads

Practical working loads for the particular job shall be established by the user with due allowance for operating conditions. These conditions include the supporting surface and other factors affecting stability, wind, hazardous surroundings, experience of personnel, etc.

6.03 CRANE STRUCTURE TESTING

These uniform test methods provide the manufacturer with a systematic nondestructive procedure for determining induced stresses in crane structures:

6.03.1 Lattice Type Booms

See SAE J987 OCT80.

6.03.2 Cantilevered Type Booms

See SAE J1063 OCT80.

6.04 CRANE INSPECTION, SERVICE AND MAINTENANCE

Inspection, servicing and maintenance are extremely important in the use of mobile cranes. Frequency requirements depend upon numerous factors, such as crane activity, severity of service, vulnerability of parts to wear and damage, and the extent to which parts may be deemed critical. Manufacturer's operator and maintenance manuals should recommend inspection, service and maintenance frequency for the particular crane involved.

SECTION 7

GLOSSARY & ABBREVIATIONS

7.0 The following is a glossary of technical terms and definitions as used in the Crane Industry.

ACCESSORY. A secondary part or assembly of parts which contributes to the overall function and usefulness of a machine.

A-FRAME. See Par. 3.01.10 and "MAST."

ALLOWABLE ROPE LOAD. The "nominal" breaking strength of the rope divided by a strength factor.

ANGLE INDICATOR (BOOM). An accessory which measures the angle of the boom above horizontal.

ATTACHMENT. See Section 4.

AXIS OF ROTATION. The vertical line around which the upperstructure rotates.

BACK HITCH GANTRY. See Par. 3.01.10.

BACKWARD STABILITY. Resistance to overturning of the machine in rearward direction. See Par. 6.01.14.

BAIL (BUCKET). A yoke or spreader hinged to sides of dragline bucket to which is attached connecting sheave or chain for hoisting and dragging operations.

BAIL BLOCK. Block attached to dragline bucket through which rope line is reeved. Also referred to as "PADLOCK."

BAIL PULL. Total pull developed at point of attachment of rope to dipper or bucket.

BOGIE AXLE. Two or more axles mounted to a frame so as to distribute the load between the axles and permit vertical oscillation of the axles.

BOOM. See Par. 4.01.1.

BOOM ANGLE. See Par. 4.01.1.3.

BOOM CHORD. A main corner member of a lattice type boom.

BOOM HOIST. Means for controlling the angle of the boom.

BOOM LACING. Structural truss members at angles to and supporting the boom chords of a lattice type boom.

BOOM LENGTH. See Par. 4.01.1.2.

BOOM SECTIONS. See Par. 4.01.1.

BOOM STOP. A device used to limit the angle of the boom to the highest recommended boom angle.

BRIDLE (FLOATING HARNESS). A frame equipped with sheaves and connected to the boom by stationary ropes usually called pendants.

BUCKET. See "CONCRETE, CLAMSHELL AND DRAGLINE BUCKET." A structural container suspended from the boom used for handling material.

CAB. An enclosure which covers the operator and/or machinery. See Par. 6.01.3.

CABLE. A flexible electrical conductor.

CANTILEVERED BOOM. A boom, fixed or telescoping, supported at some point between the boom pivot and the boom point.

CARBODY. See "UNDERCARRIAGE FRAME."

CARRIER ROLLERS. See "TRACK CARRIER ROLLERS."

CATWALK. See SAE J185 JUN81.

CENTER PIN. Vertical pin or shaft which acts as rotation centering device and connects revolving upperstructure and undercarriage.

CENTERLINE OF ROTATION. See "AXIS OF ROTATION."

CHASSIS. See "UNDERCARRIAGE."

CLAMSHELL. See Par. 4.02.

CLOSING LINE. The rope reeved from hoist drum to control closing of rope operated clamshell bucket.

CLUTCH. A friction, electromagnetic, hydraulic, pneumatic, or mechanical locking device for engagement or disengagement of power.

CONCRETE BUCKET. Bucket for handling wet concrete.

COUNTER ROTATING TRACKS. The ability of the machine to simultaneously drive tracks in opposite directions causing the undercarriage to rotate about its center.

COUNTERWEIGHT. See Par. 3.01.2.

CRANE STRUCTURE TESTING. See Par. 6.03.

CRAWLER ASSEMBLY. See Par. 3.02.1.1.

CRAWLER BEARING LENGTH AND AREA. See Par. 5.02.1.6

CRAWLER BELT. See "TRACK ASSEMBLY."

CRAWLER CHAIN. Chain used as final drive to the drive sprocket.

CRAWLER FRAME. See "TRACK FRAME."

CRAWLER UNDERCARRIAGE. See Par. 3.02.

CUSHION BLOCK. See Par. 4.05.1.7.

CUTTING EDGE (LIP). The part of the bucket which penetrates material to be excavated. Teeth may or may not be attached.

CUTTING WIDTH. The maximum width of the opening cut by a bucket measured by the overall width of the teeth or side cutters.

CYLINDER. A device which converts fluid power into linear mechanical force and motion.

DERRICKING. Operation of changing boom angle in a vertical plane. See "BOOM HOIST."

DRAGLINE BUCKET. See Par. 4.04.1.1.

DRAG ROPE. Rope for pulling in bucket in dragline operations.

DRIVE SPROCKET. A drive roller with teeth which engages matching recesses or pins (bushings) in the track assembly.

DRIVE TUMBLER. A drive roller with recesses which contact matching lugs or pins in the track assembly.

DROP HAMMER. See Par. 4.05.1.1(A).

DRUM (ROPE). A rotating cylinder with side flanges on which rope used in machine operation is wrapped.

ENCLOSURE. See Par. 3.01.3.

ENGINE HOUSE. See "ENCLOSURE."

FAIRLEAD. See Par. 4.04.1.3.

FREE FALL. Lowering of the hook (with or without load) without being coupled to the power train, with the lowering speed being controlled by a retarding device, such as a brake.

FRONT END. See Section 4.

FULL LOAD SPEED. See "RATED ENGINE SPEED."

GANTRY (A-FRAME). See Par. 3.01.10.

GOOSENECK BOOM. A boom which has an integral upper section projecting at an angle from longitudinal axis of lower section.

GOVERNED SPEED. Engine speed controlled by the power plant governor.

GRADEABILITY. See Par. 5.02.1.1 and 5.02.2.2.

GROUND CLEARANCE. See SAE J1234.

GROUND LINE. Horizontal ground plane or grade. See SAE J1234 and SAE J958 MAR81.

GROUND PRESSURE. See Par. 5.02.1.7.

GROUSER. Projecting lug(s) attached to or integral with the track shoes to provide additional traction.

GUY ROPE. A supporting rope which maintains a constant distance between the points of attachment to the two components connected by the rope.

HAMMER (PILE). See Par. 4.05.1.1.

HAMMER HEAD BOOM. A boom on which both hoist and boom suspension lines are offset from centerline of boom for load clearance.

HOIST. The process of lifting.

HOIST MECHANISM.
Boom Hoist. See Par. 3.01.9.
Load Hoist. See Par. 3.01.8.

HOLDING LINE. The cable reeved from a hoist drum for holding clamshell bucket or grapple suspended during dumping and lowering operations.

HOOK BLOCK. Block with hook attached used in lifting service. It may have a single sheave for double or triple line, or multiple sheaves for four or more parts of line. (See "LOAD BLOCK.")

HOOK ROLLERS. Rollers which prevent the lifting of the upperstructure from the undercarriage.

IDLER. Large end roller of track assembly at opposite end from drive sprocket, and which is not power driven.

IDLER ROLLER. See "IDLER, TRACK ROLLER," or "TRACK CARRIER ROLLER."

IDLER TUMBLER. Large end roller of track assembly at opposite end from drive tumbler, and which is not power driven.

INDEPENDENT FUNCTIONS. An operation independent of other functions.

JACK SHAFT. Term applied to an intermediate shaft.

JIB. See Par. 4.01.1.10.

KING PIN. See "CENTER PIN."

LACING. See "BOOM LACING."

LAGGINGS. Removable and interchangeable drum spool shells for changing hoist drum diameter to provide variation in rope speeds and line pulls. This construction is optional with manufacturer.

LATTICED BOOM. Boom of open construction with lacing between main chord members in form of truss.

LENGTH INDICATOR (BOOM). See Par. 4.01.1.6.

LIFT CAPACITY. See "RATED LOAD."

LINE PULL. The rope pull generated off a rope drum or lagging at a specified pitch diameter. See Par. 3.01.8.3.

LINE SPEED. The rope velocity at a rope drum or lagging at a specified pitch diameter. See Par. 3.01.8.3.

LIVE ROLLER CIRCLE. An assembly of multiple swing rollers free to roll between revolving upperstructure and undercarriage.

LOAD BLOCK. See "HOOK BLOCK."

LOAD DEFINITIONS. See Par. 6.02.

LOAD HOIST. See Par. 3.01.8.

LOAD HOIST DRUMS. See Par. 3.01.8.1.

LOAD HOIST LINE. Another term for "hoist line." In lifting crane service it refers to the main hoist. The secondary hoist is referred to as a "whip line."

LOAD LOWERING. See Par. 3.01.8.2.

LUFFING. Operation of changing boom angle in the vertical plane. See "BOOM HOIST."

MAGNET. See Par. 4.03.

MAGNET CONTROLLER. Electric controller for governing flow of current to magnet. Part of magnet equipment.

MAGNET GENERATOR. See Par. 4.03.1.4.

MAST. Structure hinged at or near the boom hinge and extending above the cab for use in connection with supporting a boom. Head of mast is usually supported and raised or lowered by the boom hoist ropes.

MATS. A device used for supporting machine on soft ground. Usually of timber construction.

OUTRIGGER. See Par. 3.02.2.5.

OVERHAUL. Capability to gravity lower the load block.

PENDANT. A supporting rope which maintains a constant distance between the points of attachment to the two components connected by the rope.

PERCENT OF GRADE. Measurement of slope expressed as the ratio of the change in vertical distance (rise) to the change in horizontal distance (run) multiplied by 100.

PILE. Usually a long slender member driven into the ground.

PILE CAP. An adapter between the pile driving unit and the upper end of the pile.

PILE LEAD. A structure on which the pile driving unit and pile cap may operate.

PITCH DIAMETER. Root diameter of drum, lagging or sheave, plus the diameter of the rope.

POWER CONTROLLED LOWERING. A system or device in the power train other than the load hoist brake, which can control the lowering rate of speed of the load hoist mechanism.

POWER PLANT. See Par. 3.03.

POWER TAKE-OFF. See Par. 3.04.

POWER TRAIN. The means to transfer power from one point to another accomplished by gears, chains, hydraulic pump and motor, or other means, or a combination thereof.

PRACTICAL WORKING LOADS. See Par. 6.02.2.

PRESSURE, MAXIMUM WORKING. Pressure as stated by the machine manufacturer as the maximum pressure at which a circuit shall be operated. This pressure may be limited by a relief valve or other means.

PRIME POWER SOURCE. See Par. 3.03.

PROPEL. See "TRAVEL."

RADIUS (OF LOAD). See Par. 6.01.13.2.

RATED ENGINE SPEED. See SAE J1349 DEC80.

RATED LOAD. See Par. 6.02.1.

RATING CHART:
- Lifting Crane. See Par. 4.01.6.
- Clamshell. See Par. 4.02.5.
- Magnet. See Par. 4.03.5
- Dragline. see Par. 4.04.3.

REEVING. A rope system where the rope travels around drums and sheaves.

REVOLVING UPPERSTRUCTURE (FRAME). See Par. 3.01.

RING GEAR. See "SWING GEAR."

ROLLER PATH. The surface upon which run the rollers that support revolving upperstructure. It may accommodate either cone rollers, cylindrical rollers, or live rollers.

ROPE. Refers to wire rope unless otherwise specified. See "WIRE ROPE."

SCOOP. A pivoted member of the clamshell bucket which digs and handles material.

SHOES. See "TRACK SHOES."

SIDE LOADING. A load applied at an angle to the vertical plane of the boom.

SLEWING. See "SWING," Par. 3.01.6.

SLIDE BAR. Stationary elements in a track frame which support and guide the upper track chain or shoes.

STABILITY. The ability to resist tipping. Also see Par. 6.01.13 and 6.01.14.

STABILIZER. See "OUTRIGGER."

STAY. See "PENDANT."

STEAM HAMMER. Steam driven pile hammer.

STRIPPER. Machine used for excavating overburden in open cut mining. The term is usually applied to a dragline modified or designed for greater reach, than the manufacturer's rating for the particular standard size of machine. A stripping dragline usually has an extra long boom with a correspondingly smaller bucket than one of nominal rated capacity as furnished with a boom of base rating length.

STRUCTURAL COMPETENCE. The ability of the machine and its components to withstand the stresses imposed by rated loads.

SUPERSTRUCTURE. See "UPPERSTRUCTURE," Par. 3.01.

SWING. Rotation of the upperstructure about the axis of rotation.

SWING BEARING. See Par. 3.02.1.3.

SWING BRAKE. See Par. 3.01.6.

SWING CIRCLE. See "SWING BEARING."

SWING CLEARANCE. The maximum radial distance from the axis of rotation to the outermost extension of the upperstructure.

SWING GEAR. External or internal gear that meshes with the swing pinion to provide swing motion.

SWING LOCK. See Par. 3.01.6.1.

SWING MECHANISM. The power train providing bi-directional rotation of the upperstructure.

SWING SPEED. See Par. 5.01.1.

TACKLE (HOIST). Assembly of ropes and sheaves arranged for lifting.

TAGLINE. See Par. 4.02.1.4.

TAIL SWING. See "SWING CLEARANCE."

TELESCOPING BOOM. See Par. 4.01.1.

THIRD DRUM (AUXILIARY). A hoist drum in addition to two main hoist drums, often used in pile driving.

TIPPING CONDITION. See Par. 6.01.13.

TIPPING LOAD. See Par. 6.01.13.3.

TOOTH ADAPTER. Main part of bucket or dipper to which a removable tooth is fastened.

TOOTH BASE. See "TOOTH ADAPTER."

TOOTH POINT. Removable and replaceable point for dipper or bucket tooth.

TOPPING SPEED. See "Boom Hoisting Time," Par. 3.01.9.3.

TOWER ATTACHMENT. The tower attachment consists of a luffing boom of variable length mounted on a vertical fixed tower of variable length. A mast is mounted on the tower to provide boom suspension. All tower attachment functions are provided with power from the basic crane.

TRACK ASSEMBLY. An assembly of track shoes and connecting members.

TRACK BELT. See "TRACK ASSEMBLY."

TRACK CARRIER ROLLERS. Rolling elements in/on a track frame which support and guide the upper track shoes or chain.

TRACK FRAME. The structure that supports the rollers, sprockets, or tumblers, and adjusting means in a track assembly.

TRACK ROLLERS. Rolling elements in a track frame which transfer the machine weight to the track assembly.

TRACK SHOES. The members of the track assembly that distribute the load to the supporting surface.

TRAVEL. The function of the machine moving under its own power from one location to another.

TRAVEL MECHANISM. The power train transmitting power to produce travel.

TREAD. See "TRACK SHOES."

TUMBLER. See "DRIVE TUMBLER" and "IDLER TUMBLER."

TURNING DIAMETER. See Figure 1, SAE J958 MAR81 and SAE J695b.

TURNTABLE. See "UPPERSTRUCTURE," Par. 3.01.

UNDERCARRIAGE. See Par. 3.02.

UNDERCARRIAGE FRAME. The principal structural frame of the undercarriage.

UPPERSTRUCTURE. See Par. 3.01.

UPPERSTRUCTURE FRAME. See Par. 3.01.1.

WHEELED UNDERCARRIAGE. See Par. 3.02.2.

WHEELED UNDERCARRIAGE CLEARANCE DIAMETER. See SAE J695b.

WHIP LINE. Secondary hoist line. Also see "LOAD HOIST LINE."

WIRE ROPE. A flexible, multi-wired member usually consisting of core member around which a number of multi-wired strands are "laid" or helically wound.

WORKING EQUIPMENT. See Section 4.

WORKING WEIGHT. Weight of machine in working order with complete front end equipment and one-half tank of fuel. Machine configuration shall be specified.

ABBREVIATIONS AND CONVERSIONS

Symbol	Unit of Measure	Conversion Factor
Metric (English)	**Metric (English)**	**Metric to English**
m (ft)	meter (feet)	m x 3.281
L (gal)	liter (gallon)	L x .2642
L (qt)	liter (quart)	L x 1.0568
L/min (gpm)	liters per minute (gallons per minute)	L/min x .2642
kW (hp)	kilowatt (horsepower, SAE)	kW x 1.341
Hz	hertz	—
mm (in)	millimeters (inches)	mm x .03937
cm^3 (in^3)	cubic centimeters (cubic inches)	cm^3 x .06102
rpm	revolutions per minute	—
m^3 (yd^3)	cubic meters (cubic yards)	m^3 x 1.308
kg (lb) weight	kilograms (pounds)	kg x 2.2046
N (lb) force	newtons (pounds)	N x .2248
km/h (mph)	kilometers per hour (miles per hour)	km/h x .6214
kPa (psi)	kilopascal (pounds per square inch)	kPa x .1450
deg	degrees	—
sec	seconds	—

ADDENDUM A
Crane Rating Classification

Classification -- Lifting cranes shall be classified by a symbol, consisting of two numbers based on crane rated loads (par. 4.01.2) in the direction of least stability, with outriggers set if the crane is so equipped.

(1) The first number of the group shall be the crane rating radius, in feet, for the maximum rated load, with base boom length.

(2) The second number of the group shall be the rated load (expressed in pounds divided by 100, and rounded off to the nearest whole number) at 40-ft. radius, with 50-ft. boom length.

Example -- To illustrate the above method of classification, assume a truck crane rated 40 tons at 12-ft. radius with base boom length, and 19,600 pounds at 40-ft. radius with 50-ft. boom length. The classification of this crane would be:

"40-ton truck crane (Class 12-196)"

The number 12 represents the radius, in feet, for the 40-ton rated load, and the number 196 represents the rated load in pounds, at 40-ft. radius, divided by 100. This method is illustrated below in Figure A-1.

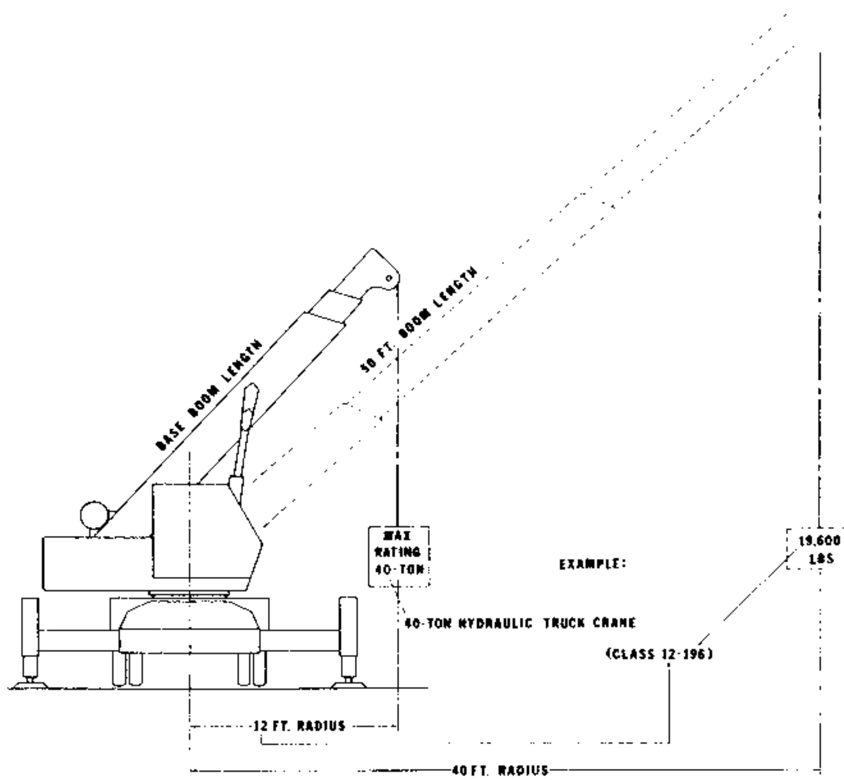

Figure A-I.
Method of Determining Crane Rating Classification.

CALIFORNIA

Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the state of California to cause cancer, birth defects, and other reproductive harm.

WARNING: Battery posts, terminals, and related accesories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm. **Wash hands after handling.**