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**Document Name:** PCSA 1: Mobile Crane and Excavator Standards

**CFR Section(s):** 29 CFR 1926.602(b)(3)

**Standards Body:** Power Crane and Shovel Association

**Official Incorporator:**
THE EXECUTIVE DIRECTOR
OFFICE OF THE FEDERAL REGISTER
WASHINGTON, D.C.
MOBILE POWER CRANE
AND EXCAVATOR STANDARDS

PCSA STANDARD NO. 1

DEVELOPED AND COMPILED BY

PCSA
A Bureau of Construction Industry Manufacturers Association

Marine Plaza—Suite 1700
111 E. Wisconsin Avenue
Milwaukee, Wisconsin 53202
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.
FOREWORD

These standards and recommendations are developed by the Standards Committee of the Power Crane and Shovel Association, a bureau of the Construction Industry Manufacturers Association. They are intended to encompass only mobile power cranes and excavators described in the SCOPE.

The purpose of this manual is to present a co-ordinated set of standards and recommendations which can serve as a guide to manufacturers of the equipment, users, regulatory authorities, and code writing agencies. It is further intended to update and expand similar information contained in Commercial Standard CS90-58, issued by the United States Department of Commerce, which has long served as a guide to the crane-shovel industry.

Particular emphasis is placed on the latest recommended practices of the industry, to encourage proper construction, use, and application of mobile power cranes and excavators. 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, Inc.
Construction and Industrial Machinery Technical Committee
Two Pennsylvania Plaza
New York, New York 10001

ANSI Standards Committee B30
The American Society of Mechanical Engineers
United Engineering Center
345 East 47th Street
New York, New York 10017

Construction Industry Manufacturers Association
Bucket Manufacturers Bureau
Marine Plaza — Suite 1700
111 E. Wisconsin Avenue
Milwaukee, Wisconsin 53202

Standards Committee,
PCSA
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SECTION 1
PURPOSE

1.01 This Standard is designed to serve the following purposes:
(1) To establish uniform methods and procedures for the
guidance of manufacturers, distributors and users in
specifying mobile power cranes and excavators and in
presenting data concerning them.
(2) 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.

(3) To promote fair competition.

(4) To re-affirm generally recognized and accepted rules of
good safety practice in design, construction, mainte-
nance, application and operation of the types of equip-
ment covered herein.

(5) To provide means for identification and certification of
products which meet the requirements of this Standard.

SECTION 2
SCOPE

2.01 TYPES AND SIZES
This standard applies to mobile power cranes and excavators
of the full revolving type, which may or may not be convertible.
They may be crawler mounted or rubber tire carrier mounted
as herein defined. Front end operating equipment may be for
lifting crane, clamshell, magnet, dragline, pile driver, shovel
and hoe, as herein described, or any adaptations of the same
which retain the basic characteristics. It includes so-called
“commercial” sizes, commonly known as rope operated
machines, generally equipped with friction clutches & brakes.

2.02 UNIFORM SPECIFICATION DATA
The standard provides illustrations, tables, and lists of items
which establish the scope and arrangement of important spec-
fication requirements and dimensions. The uniform presen-
tation in manufacturer's literature of data on the major
operating components makes possible convenient and com-
prehensive comparisons of the characteristics of the ma-
chines. Nomenclature and definitions are included, together
with a glossary, to aid in the interpretation of terms used in
the trade.

2.03 REQUIREMENTS
The requirements cover features of construction, operation,
control, stability, rating and safety. The following require-
ments which need particular attention in complying with this
standard are printed in boldface type where they occur:

(1) Requirements which apply to design, construction, per-
formance and safety of the equipment.

(2) Requirements which apply to information that the manu-
ufacturer shall furnish on request, if it is not included
with his current printed specifications and sales literature.

Figure 1. Label adopted by the Power Crane and Shovel Association.

2.04 COMPLIANCE
Methods of certification and labeling as evidence of full
compliance with provisions of “P.C.S.A. standard no. 1” and
“commercial standard CS90-58” are provided. A label used
in the Industry is illustrated in Figure 1.

Manufacturers that comply with either “P.C.S.A. standard
no. 1” or “commercial standard CS90-58” or both, may so
indicate on their products and literature.

Although certification and labeling are intended only for
machines which do 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,
compliance certification and labeling are permissible when
deviations are clearly stipulated in specifications or con-
tracts and, where applicable, are shown on capacity plates
or other signs on the machine.
3.01 BASIC OPERATING COMPONENTS
The machines covered in this standard, when equipped for work, consist of four main operating components; (1) revolving superstructure, (2) mobile base mounting, (3) power plant, (4) front end operating equipment, as follows:

3.01.1 Revolving Superstructure — The revolving superstructure includes the rotating frame, and machinery mounted thereon, common to all functional operations as described in paragraphs 4.01 through 4.07.

3.01.2 Mobile Base Mounting — The mounting is the base for the revolving superstructure. It provides mobility for the machine while in operation, and while moving from job to job. Two types are covered herein; (1) crawler mounting (paragraphs 5.01 through 5.07), and (2) rubber tire carrier mounting (paragraphs 5.08 through 5.20.2). See also paragraphs 5.21 and 5.22 for outriggers.

3.01.3 Power Plant — The power plant (or plants) includes the prime mover which may be an internal combustion engine or electric motor, and the power take-off which may be a friction clutch, a fluid coupling, a hydro-dynamic torque converter, a hydrostatic or an electric generator type, and may or may not include a multiple speed gear box, as described in paragraph 6.01 through 6.03.3.

3.01.4 Front End Operating Equipment — Several types of front end attachments may be applied to the basic machine for performing various types of crane and excavating functions; such as lifting crane, clamshell, magnet, dragline, pile driver, shovel, hoe or any adaptations of the same which retain the basic characteristics. These attachments are described in paragraphs 7.0 through 7.74. Convertible and interchangeable boom equipment and other accessories are generally, but not necessarily available for these operations.

SECTION 4
REVOLVING SUPERSTRUCTURE

4.01 REVOLVING SUPERSTRUCTURE
The revolving superstructure is defined as the rotating frame and machinery located thereon, except power plant, for operating the machine.

4.02 MAIN DRUMS
Main drums are used for lifting and lowering loads, to operate excavating attachments, and for other purposes. Two main drums and operating mechanism usually are provided. Some manufacturers offer a third drum for special operations.

4.02.1 Main Drum Clutches — Main drum clutches when properly maintained and adjusted shall be capable of developing 110% of permissible line pull.

4.02.2 Main Drum Brakes — Main drum brakes when properly maintained and adjusted, shall be capable of holding 110% of permissible line pull. The brakes shall be capable of maintaining the load in suspended position, in normal operating cycles.

4.02.3 Load Lowering — Load lowering is controlled by brakes acting on the drums. For lifting crane service, some manufacturers offer “Power Controlled Lowering” by a reversing mechanism in the power train to one or more of the drums, to provide a limited lowering speed and reduce demand on the drum brake. The reversing mechanism shall be capable of retarding the load to the lesser of two values; namely 125% of permissible line pull per paragraph 4.02.5, or available retarding ability of power plant and machinery.

4.02.4 Available Line Pull — The line pull in pounds (lbs.) 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 power plant output torque as defined in 6.03.1.

4.02.5 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.

4.02.6 Available Line Speed — The line speed in feet per minute (fpm) at the drum, with specified pitch diameter drum or lagging (average pitch diameter for tapered drum), for the first layer of rope, developed by power plant output speed as defined in 6.03.1.

4.02.7 Minimum ratio of lifting crane load hoist drum pitch diameter to nominal rope diameter shall not be less than 18 to 1 specified in SAE Standard J881 (See Appendix E).

4.03 BOOM HOIST
Boom hoist is defined as the rope drum and its drive, or other mechanism for controlling the angle of the boom. Boom lowering may be controlled by a brake only, or in combination with engagement to the power train. The latter is mandatory for lifting crane service.

4.03.1 Independent Boom Hoist — When a boom hoist drive is independent of all other functions, it usually is designated as the independent type.
4.03.2 The boom hoist shall be capable of suspending the boom and rated load with recommended reving, without attention from the operator, and allow lowering only when under operator’s control.

4.03.3 Braking mechanism is required regardless of the type of drive. When boom lowering is controlled by brake only, a ratchet and pawl shall be provided to prevent lowering of boom when machine is idle.

4.03.4 Minimum ratio of boom hoist drum and sheave pitch diameters to nominal rope diameters shall not be less than 15 to 1 specified in SAE Standard J881 (See Appendix E).

4.03.5 Boom Hoisting Time — Crane boom hoisting and lowering times between minimum and maximum boom angles may be specified without a suspended load. The booming time shall be measured within the included angle of no less than 20° from horizontal to no greater than 70° from horizontal, to provide room for overtravel in a proof test.

4.04 SWING
Swing is defined as the function of revolving the superstructure of the machine.

4.04.1 Swing Speed — Swing speed is defined as the speed, in revolutions per minute, at which the revolving superstructure rotates. The manufacturer shall specify rated swing speed as defined in 6.03.1.

4.04.2 Swing Lock and Swing Brake — A swing lock is a mechanical device to lock the revolving superstructure to the mounting in established positions. A swing brake is a friction device to hold the revolving superstructure in any desired position relative to the mounting. A swing lock or swing brake capable of preventing rotation under normal working conditions shall be provided. The manufacturer shall specify whether swing lock, swing brake, or both are furnished.

4.05 GANTRY
A gantry is a structure mounted on the revolving superstructure of the machine to which the boom supporting ropes are attached. Gantries may be available in different heights and types for various conditions. Manufacturer shall specify conditions of use, and state whether fixed or lowerable.

4.06 CONTROLS
All controls essential to operation shall be located within easy reach of the operator while seated at his station. The arrangement of controls shall be such as to provide proper co-ordination of hand and foot movements required by the various types of front end operating equipment. See Appendix D for SAE Recommended Practice J983.

4.06.1 Hand Levers — Hand levers for hoist control, boom hoist control, swing control, and crowd control shall be provided with means for holding in neutral position, without use of positive locks.

4.06.2 Foot Pedals — See paragraph 4.02.2.

4.06.3 Control Forces and Movements — When controls and corresponding controlled elements are properly maintained and adjusted, and the machine is operated within the manufacturer’s ratings with recommended reving, the following shall be provided under normal operation:

A. Lifting Crane Service — Forces not greater than 35 lbs. on hoist, boom hoist, and swing hand levers. Forces not greater than 50 lbs. on hoist brake foot pedals.

B. Excavator Service — Forces not greater than 65 lbs. on hand levers and foot pedals.

C. Travel distance on hand levers not greater than 14" from neutral position on two way levers and not greater than 24" on one way levers. Travel distance on foot pedals not greater than 10".

4.07 REVOLVING SUPERSTRUCTURE AND CAB DIMENSIONS
See Figure 3 in Appendix A.
SECTION 5

MOBILE BASE MOUNTINGS

CRAWLER MOUNTINGS

5.01 CRAWLER MOUNTING
A crawler mounting is defined as two continuous, parallel crawler belts, consisting of a series of tread shoes or links encompassing rollers and drive tumbler wheels, supporting a base frame which houses the propelling mechanism, driven and controlled from revolving superstructure.

5.02 BEARING LENGTH AND AREA
The effective bearing length of each crawler on the ground is computed as not more than the normal distance from center to center of the crawler end sprockets or tumbler wheels at midpoint of adjustment range \( J_1 \), plus 35 percent of the overall crawler height \( M \) at center of end sprocket or tumbler wheels. The total bearing area is computed by multiplying the effective crawler bearing length (as above defined) of both crawlers by the width of tread shoes. See Figure 2, and also Appendix B.

[Diagram: Figure 2.]

5.03 GROUND PRESSURE
Ground pressure is the average pressure in pounds per square inch derived by dividing the total working weight of the machine with complete front end equipment, but without load, by the crawler bearing area.

5.04 PROPEL DRIVE
Travel power is furnished by the power plant on the revolving superstructure, through the axis of rotation, and is distributed to the two crawler belts through means permitting steering. Propel drive may be either single or multiple speed. When the propel drive from the power plant is separate from all other functions, it is usually designated as independent propel.

5.04.1 Gradeability — Machines without load shall be capable of climbing a 30 percent grade (30 feet rise in 100 feet horizontal) on smooth, firm, dry surface, free of loose material, providing the required traction.

5.04.2 Speed — Manufacturer shall specify travel speed (or speeds if more than one is available) developed by power plant output speed as defined in paragraph 6.03.1.

5.04.3 Steering — Machine shall be capable of being steered either right or left in either direction of travel. Control shall be from the operator's position on revolving superstructure.

5.05 TRACTION LOCK OR BRAKE
A traction lock or brake shall be provided capable of holding the machine stationary under normal working conditions, and on any grade the machine is capable of negotiating. Manufacturer shall specify the type of holding means provided.

5.06 CRAWLER MACHINE DIMENSIONS
Manufacturer shall specify dimensions shown in Appendix A, Figure 3.

5.07 GROUND CLEARANCE
See Figure 3 in Appendix A and Paragraph 10 in Appendix B.

RUBBER TIRE CARRIER MOUNTINGS

5.08 TRUCK TYPE MOUNTING
A rubber-tire carrier supported by two or more axles and having the general characteristics of a heavy-duty truck, upon which is mounted a revolving superstructure with appropriate front end equipment, and which is controlled for over-the-road travel from a cab mounted on the carrier. It generally has separate engines for carrier and superstructure.

5.09 SELF PROPELLED MOUNTING
A rubber-tire carrier supported by two or more axles upon which is mounted a revolving superstructure with appropriate front end equipment, and which is controlled for travel from the cab on the revolving superstructure. The carrier generally is driven by the engine on the superstructure.

5.10 WHEEL AND AXLE ARRANGEMENT
Rubber tire carrier mountings are classified by a double number, the first indicating the number of wheels, and the second, the number of wheels which are driven. For example:
- 4 x 4 signifies the mounting has four wheels, all of which are powered for travel.
- 6 x 4 signifies the mounting has six wheels, four of which are powered for travel.

5.11 POWER EQUIPMENT
Carriers covered by this standard are usually powered by internal combustion engines of various types.
5.11.1 When carrier has separate engine, power plant shall be specified according to section 6.

5.11.2 When there is no engine in the carrier, travel power is furnished from the revolving superstructure, through the axis of rotation, to one or more of the axles. When such drive from the superstructure is separate from all other functions, it usually is designated as independent propel.

5.12 GRADEABILITY
Gradeability is defined as the grade in percent (feet rise in 100 feet horizontal) which the machine can negotiate on a smooth, firm, dry surface, free of loose material, providing the required traction. When gradeability is specified, it should be determined in accordance with SAE Recommended Practice J688 “Truck Ability Prediction Procedure.” See Appendix C.

5.13 TRAVEL SPEED
Manufacturer shall specify the number of gear speeds in forward and reverse, and vehicle speeds in lowest and highest gears determined in accordance with SAE recommended practice J688 “Truck Ability Prediction Procedure” for “good class 1 road” at sea level. See Appendix C.

5.14 BRAKES
Service brakes shall be provided to properly bring the machine to a stop from normal travel speeds. Means shall be provided to adequately hold the machine stationary during working cycles. Means shall also be provided to hold the machine on any grade which it can negotiate.

5.15 TURNING ABILITY
Manufacturer shall specify the vehicle clearance circle. See Figure 1 in Appendix A.

5.16 SPECIAL REGULATIONS
When a rubber tire mounted machine is to operate on public streets or highways, compliance with local regulations governing such use is the purchaser’s responsibility.

5.17 DIMENSIONS
See Figure 2 in Appendix A.

5.18 GROUND CLEARANCE
See SAE J894 in Appendix B.

5.19 REMOTE CONTROL
When supplied on a truck type carrier, remote control provides control of the carrier functions from the revolving superstructure. Carrier functions controlled from the revolving superstructure shall be specified.

5.20 RAIL-WHEEL ATTACHMENT
Rubber tire mounted machines sometimes are provided with auxiliary, retractable, flanged wheels for use on tracks for right-of-way construction and maintenance where space does not permit off-track operation. Basically they are rubber tire mounted machines as covered by Section 5.08.

5.20.1 Propel Drive — 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.

5.20.2 Special Regulations — Compliance with local regulations governing the use of such machines both on public highways and public carrier tracks is the purchaser’s responsibility.

OUTRIGGERS

5.21 OUTRIGGERS
Outriggers are members attached to the carrier frame to increase stability. Extendible type can further increase stability by increasing the size of the supporting base.

5.22 MANUFACTURER SHALL SPECIFY:
A. Number and location of outriggers.
B. Whether outriggers are fixed or extendible; if extendible, whether telescoping or hinged, and whether manually or by power.
C. Whether jacks and supporting floats are furnished; if furnished, whether jacks are manual or powered.
D. Whether outrigger boxes are permanently attached or removable.
SECTION 6
POWER PLANT

6.01 POWER PLANT
The power plant is defined as the prime-mover, and power take-off.

6.02 PRIME-MOVER
Generally internal combustion engine or electric motor.

6.02.1 Internal Combustion Engine Data. Manufacturer shall specify:
(1) Engine make and model number.
(2) Spark ignition or diesel.
(3) Number of cylinders, bore and stroke, displacement, two or four cycle.
(4) Naturally aspirated, blown, supercharged, or turbocharged. Special characteristics, such as after-cooling, if employed.
(5) Liquid or air cooled.
(6) Type of starting equipment.
(7) Engine speed (RPM) related to paragraph 6.03.1.

6.02.2 Internal Combustion Engine Installation
(1) The exhaust should be directed away from the machine operator.
(2) Hot exhaust manifolds and pipes that may be contacted by personnel in performance of their regular duties should be guarded.

6.02.3 Internal Combustion Engine Power at High Altitude. — Since 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 3,000 feet above sea level.

6.02.4 Electric Motor Data — Manufacturer shall specify:
(1) Alternating or direct current, voltage, and frequency.
(2) Type of motor.
(3) Motor rating (continuous, or intermittent time).
(4) Type of starter.

6.02.5 Electric drive machines shall be adequately grounded between revolving superstructure and mounting base, either by inherent means or other grounding device.

6.02.6 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.

6.03 POWER TAKE-OFF
Power take-off from prime-mover may be mechanical drive, hydrodynamic drive (fluid coupling or torque converter), hydrostatic drive, or electric drive (generator).

6.03.1 Mechanical and Hydrodynamic Drives.—Net delivered horsepower at the power take-off output shaft shall be specified. Machine performance specifications shall be based on torque and speed for this power.

6.03.2 Mechanical and hydrodynamic drives for internal combustion engines.
(1) The power take-off shall include a friction disconnect clutch, controlled from the operator’s station.
(2) In revolving superstructure machinery drives, the disconnect clutch shall be provided with a device requiring positive manual effort to engage. Where a transmission having neutral position is used in combination with an engine clutch, the clutch may be of the spring loaded type.

6.03.3 Hydrostatic and Electric Drives — There are too many possible variations of these drives to establish standards of performance or requirements. Manufacturers should recognize the intent of this standard in developing designs and specifications.
SECTION 7
FRONT END OPERATING EQUIPMENT

The types of front end equipment included in this standard are lifting crane, clamshell, dragline, magnet, pile driver, shovel, and hoe, or any adaptation of the same which retains the basic characteristics.

7.0 COMMON DATA FOR LIFTING CRANE, CLAMSHELL, DRAGLINE, MAGNET, AND PILE DRIVER EQUIPMENT.

7.01 BOOM EQUIPMENT
The basic boom structure usually consists of two sections, upper and lower, between which additional sections may be added to increase its length. The boom is pivotally mounted on the revolving superstructure, and is adjustable as to angle by boom hoist or derricking ropes or other means. It is equipped with boom point sheaves and other parts as required.

7.01.1 Boom Length — (See “X” in Appendix A, Fig. 6) Boom length is the straight line distance from centerline of boom foot pin to centerline of boom point load hoist sheave pin.

7.01.2 Boom Angle — (See “Z” in Appendix A, in Fig. 6) Boom angle is the angle above horizontal of the straight line joining the centerline of boom foot pin and centerline of boom point load hoist sheave pin.

7.01.3 Boom Hoist Ropes (also called Derricking Ropes).
(1) 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.
(2) 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.
(3) Mast Suspension—Similar to Pendant Suspension, except that the floating boom harness is supported by a strut hinged near the boom foot.

7.02 TIPPING CONDITION
A machine is considered to be at the point of tipping when a balance is reached between the overturning moment of the load and the stabilizing moment of the machine when on a firm, level supporting surface.

Note: For suggested test procedure see SAE Recommended Practice J765 “Crane Load Stability Test Code,” Appendix F.

7.02.1 When outriggers are used, wheels or crawler tracks within the boundary of the outriggers shall be relieved of all weight by the outrigger jacks or blocking.

7.02.2 Radius of Load — The horizontal distance from a projection of the axis of rotation to the supporting surface, before loading, to the center of vertical hoist line or tackle with load applied.

7.02.3 Tipping Load is the Load Producing a Tipping Condition at a Specified Radius. Weights of hook, hook blocks, slings, etc. except the hoist rope itself, shall be considered part of the load.

7.03 BACKWARD STABILITY (counterweight limitations)
To maintain a reasonable margin of backward stability with the subject equipments, standard counterweighting shall be limited by the weight distribution specified below, established when the machine is on a firm, level supporting surface; equipped with the shortest recommended boom set at minimum recommended radius; with hook, hook block, bucket, or other load handling equipment resting on the ground; and with outriggers, if provided, retracted and free of the ground.

(1) Crawler cranes
The horizontal distance between the center of gravity of the crane and the axis of rotation shall not exceed 70 percent of the radial distance from the axis of rotation to the backward tipping fulcrum in the least stable direction.

(2) Truck and wheel mounted cranes
A. With the longitudinal axis of the rotating superstructure of the crane at 90 degrees to the longitudinal axis of the carrier, the total load on all wheels on the side of the carrier under the boom shall not be less than 15 percent of the total weight of the crane.

B. 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 be not less than 15 percent of the total weight of the crane.

7.04 LOAD DEFINITIONS:
(1) Rated Load — Rated loads at specified radii with the subject equipment are the lesser of a specified percentage of tipping loads or the machine's structural competence as established by the manufacturer, and are the maximum loads at those radii covered by the manufacturer's warranty.
(2) Net Load — Net loads are the weights of material that can be handled, determined by deducting the weight of auxiliary load handling equipment such as hooks, hook-blocks, slings, buckets, magnets, pile driver leads, etc. from the rated loads.

(3) 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 ground and other factors affecting stability, wind, hazardous surroundings, experience of personnel, etc.

7.10 LIFTING CRANE

7.11 LIFTING CRANE EQUIPMENT

(See Appendix A, Fig. 6) Machines with lifting crane attachments are used to raise, lower, and place miscellaneous loads.

7.11.1 Boom — See paragraph 7.01

7.11.2 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.

7.11.3 Boom Stops — Stops shall be provided to resist the boom falling backwards on a grade, in a high wind, or in case the hitch fails.

(1) A fixed or telescoping bumper
(2) A shock absorbing bumper

7.11.4 Boom Hoist Disconnect — A boom hoist disconnect or shut-off should be provided to automatically stop the boom hoist when the boom reaches a predetermined high angle.

7.11.5 Load Hooks — Load hooks and hook blocks shall be counter-weighted to overhaul the line from the highest hook position. All hooks and hook blocks shall be permanently labeled with their rated capacity. Load hooks may be equipped with safety latches. Load hooks on multiple part blocks may be equipped with a swivel.

7.11.6 Jib or Boom Tip Extension — (See "19" in Appendix A, Fig. 6) An extension attached to the boom head to provide added boom length for handling specified loads. The jib may be in line with the boom or offset.

7.12.1 Rated Loads—(See par. 7.04 [1]) Lifting crane rated loads at specified radii shall not exceed the following percentages of tipping load (par. 7.02.3) at specified radius:

(1) Crawler mounted machines 75%
(2) Rubber tire mounted machines 85%
(3) Machines on outriggers 85%

Rated loads shall be based on the direction of minimum stability from the mounting, unless otherwise specified. No load shall be lifted over the front area except as approved by the crane manufacturer.

7.12.2 Classification — Lifting cranes shall be classified by a symbol, consisting of two numbers based on crane rated loads (par. 7.12.1) 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 3.

Figure 3. Method of Determining Crane Rating Classification.
7.13.1 Allowable Rope Loading — The strength factors for wire ropes shall not be less than those specified in SAE Standard J959, Appendix G.

<table>
<thead>
<tr>
<th></th>
<th>Running</th>
<th>Standing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supporting Rated Load</td>
<td>3.5</td>
<td>3.0</td>
</tr>
<tr>
<td>Supporting Boom and Attachments at Gantry Height to Minimize Travel Clearance</td>
<td>3.5</td>
<td>3.0</td>
</tr>
<tr>
<td>Supporting Boom at Ground Level for Erection</td>
<td>3.0</td>
<td>2.5</td>
</tr>
</tbody>
</table>

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 crane rated load (par. 7.12.1).

7.13.2 Sheave Diameters — Ratios of sheave pitch diameter to nominal rope diameter shall not be less than those specified in SAE Standard J881, Appendix E.

<table>
<thead>
<tr>
<th>Sheave Pitch Diam.</th>
<th>Minimum ratio</th>
<th>Rope Diam.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load hoisting sheaves on boom</td>
<td>18.0 to 1</td>
<td></td>
</tr>
<tr>
<td>Load hoisting sheaves in lower block</td>
<td>16.0 to 1</td>
<td></td>
</tr>
<tr>
<td>Boom hoisting sheaves</td>
<td>15.0 to 1</td>
<td></td>
</tr>
</tbody>
</table>

7.13.3 Drum Diameters — For drum to rope diameter ratios, see par. 4.02.7 and 4.03.4.

7.14 Crane rating chart — A load rating chart shall be located on the crane to be available to the operator from his position at the control stand. It shall include:

- Crane classification (see par. 7.12.2)
- Rated crane loads for recommended boom lengths at recommended radii.
- Basis of crane rating: firm, level, and uniform supporting surface (par. 7.02); rating percentage (par. 7.12.1); net load and practical working load definitions (par. 7.04 [2] and 7.04 [3]). 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 par. 7.13.1).
- Deductions to be made from rated loads on the boom when attachments such as jibs are mounted.
- Data on jibs: Available lengths, permissible offsets, and rated loads.

7.15 Lifting crane data — the manufacturer shall furnish the following data:

- A. Data on load rating chart (see par. 7.14)
- B. Height of boom point load hoist sheave pin
- C. For each hoist drum:
  1. Drum Pitch Diameter
  2. Available Line Pull (see par. 4.02.4 and 6.03.1)
  3. Permissible Line Pull (see par. 4.02.5 and 6.03.1)
  4. Available Line Speed (see par. 4.02.6 and 6.03.1)
  5. Rope Spooling Capacity

7.20 CLAMSHELL CRANE

7.21 CLAMSHELL EQUIPMENT

(See "21" in Fig. 6, Appendix A) Machines with clamsHELL attachments are used to load material from stock piles, 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 attachments are included in this classification.

7.21.1 A clamsHELL 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. ClamsHELL buckets are controlled by a holding line reeled 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 reeled over a boom point sheave and ending in a force amplifying tackle or other means between the head assembly and scoop hinge to close the bucket. Because digging ability is largely dependent on bucket weight, buckets are supplied in various weight classes ranging from light for easily dug stock piled materials, to heavy for excavating hard pan and the like.

7.21.2 Boom — See paragraph 7.01

7.21.3 Boom Angle Indicator — If specified, see 7.11.2

7.21.4 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.

7.22 CLAMSHELL RATING

Shall be the lesser value as determined by paragraphs 7.22.1, 7.22.2, or 7.22.3.

7.22.1 Rated Loads — (See par. 7.04[1]) The combined weight of clamsHELL bucket and contents shall not exceed 75% of tipping load (par. 7.02.3) at specified radius for all mountings. For normal operation it is recommended that the combined weight of bucket and contents for any given radius of operation should not exceed 90% of Crane Rated Load for Crawler Mounting par. 7.12.1(1), and 80% of Crane Rated Load for Rubber Tire Mounting par. 7.12.1(2). Also see par. 7.04(2) and 7.04(3).

7.22.2 Maximum ClamsHELL Load — The combined weight of bucket and contents shall not exceed the limits imposed by allowable rope loading (par. 7.23.1). For normal operation the combined weight of bucket and contents should not exceed 70% of the available closing line pull (par. 4.02.4 and 6.03.1)

7.22.3 The manufacturer should state any other limitations on bucket size that apply to particular machines, and when requested, to particular operations.
7.23.1 Allowable Rope Loading — The rope strength factor shall be considered to be the total "nominal" breaking strength of all active 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 Par. 7.13.1 for allowable rope loading.

Note: Term "Active Ropes" is used because generally the holding line cannot be included as support for a loaded bucket, but in some cases it is used.

7.23.2 Sheave Diameters — Ratios of sheave pitch diameter to nominal rope diameter shall not be less than those specified in SAE Standard J881, Appendix E.

<table>
<thead>
<tr>
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<th>Rope Diam.</th>
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</thead>
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<td>18.0 to 1</td>
</tr>
<tr>
<td>Closing tackle sheaves in bucket</td>
<td>16.0 to 1</td>
</tr>
<tr>
<td>Boom hoisting sheaves</td>
<td>15.0 to 1</td>
</tr>
</tbody>
</table>

7.24 CLAMSHELL RATING CHART

A load rating chart shall be located on the crane, available to the operator from his position at the control stand. It shall include:

Rated clamshell loads for recommended boom lengths at recommended radii.

Basis of clamshell rating: firm, level, and uniform supporting surface (par. 7.02); rating percentage (par. 7.22); net load and practical working load definitions (par. 7.04[2] and 7.04[3]).

Maximum weight of clamshell bucket and contents (par. 7.22)

Notes on the crane rating chart (par. 7.14) satisfy this requirement.

7.25 CLAMSHELL DATA

The manufacturer shall furnish the following data:

A. Data on clamshell rating chart (see par. 7.24)

B. For holding and closing drums:

1. Drum Pitch Diameter
2. Available Line Pull (see par. 4.02.4 and 6.03.1)
3. Permissible Line Pull (see par. 4.02.5 and 6.03.1)
4. Available Line Speed (see par. 4.02.6 and 6.03.1)

7.26 CLAMSHELL BUCKET CAPACITY RATING

The following formula has been established by the Bucket Manufacturers Bureau of the Construction Industry Manufacturers Association.

All dimensions are taken on the inside of a bucket and are expressed in inches.

As all buckets will heap differently in the various materials they are called upon to handle, The Bucket Manufacturers Bureau does not recognize "heaped load" ratings by manufacturers. The bucket user is encouraged to seek actual or estimated performance data for the particular material he is interested in handling.

7.27 MAGNET CRANE

7.31 MAGNET EQUIPMENT

(See "24" in Fig. 6, Appendix A) 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.

7.31.1 An electro-magnet, generally direct current, is suspended from the crane hook; is powered from a generator on the revolving superstructure; and is regulated at the operator's station.

7.31.2 Boom — see paragraph 7.01

7.31.3 Boom Angle Indicator — if specified, see 7.11.2.

7.31.4 Magnet Generator — May be driven by the prime mover on the revolving superstructure or by a separate engine.

7.31.5 Cable Reel — A drum on which the electric cable supplying the magnet is wound to take up slack cable.

7.32 MAGNET LOAD RATING

Shall be the lesser value as determined by paragraphs 7.32.1, 7.32.2, or 7.32.3.
7.32.1 Rated Loads—(See par. 7.04[1]) *The combined weight of magnet and load shall not exceed 75% of tipping load* (par. 7.02.3) *at specified radius for all mountings*. For normal operation handling scrap or pig iron it is recommended that the combined weight of magnet and load for any given radius of operation should not exceed 90% of Crane Rated Load for Crawler Mounting par. 7.12(1) and 80% of Crane Rated Load for Rubber Tire Mounting par. 7.12.1(2). Also see par. 7.04(2) and 7.04(3).

7.32.2 Maximum Magnet Load — *The combined weight of magnet and load shall not exceed the limit imposed by allowable rope loading* (par. 7.23.1). For normal operation the combined weight of magnet and load should not exceed 70% of the available line pull (par. 4.02.4 and 6.03.1).

7.32.3 The manufacturer should state any other limitation which may apply to a particular machine or operation.

7.33.1 Allowable Rope Loading — (Same as 7.13.1)

7.33.2 Sheave Diameters — (Same as 7.13.2)

7.34 MAGNET CRANE RATING CHART
Use Clamshell chart (par. 7.24)

7.35 MAGNET CRANE DATA
The manufacturer shall furnish the following data:
A. Data on magnet rating chart (see par. 7.34)
B. For hoist drum:
   (1) Drum Pitch Diameter
   (2) Available Line Pull (see par. 4.02.4 and 6.03.1)
   (3) Permissible Line Full (see par. 4.02.5 and 6.03.1)
   (4) Available Line Speed (see par. 4.02.6 and 6.03.1)
C. For magnet generator:
   (1) Driven by main engine or separate engine
   (2) AC or DC
   (3) Voltage
   (4) KW Rating

7.40 DRAGLINE

7.41 DRAGLINE EQUIPMENT
(See “22” in Fig. 6, Appendix A) Machines with dragline attachments are generally used to excavate material from below the grade on which the machine is placed.

7.41.1 A dragline bucket is loaded by the drag rope pulling it toward the machine, it 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 or cemented formations.

7.41.2 Boom — See paragraph 7.01

7.41.3 Fairlead — A combination of sheaves and or rollers mounted at the front of the machine to guide the drag rope to the drag drum.

7.42 DRAGLINE LOAD RATING
Shall be the lesser value as determined by paragraphs 7.42.1, 7.42.2, or 7.42.3.

7.42.1 Rated Loads—(See par. 7.04[1]) the combined weight of dragline bucket and contents shall not exceed 75% of tipping load (par. 7.02.3) at specified radius, for all mountings (100% of Crane Rated Load for Crawler Mounting par. 7.12.1(1), and 90% of Crane Rated Load for Rubber Tire Mounting (par. 7.12.1(2)). Also see par. 7.04(2) and 7.04(3).

7.42.2 Maximum Dragline Load — For normal operation the combined weight of bucket and contents should not exceed 60% of the available hoist line pull (par. 4.02.4 and 6.03.1).

7.42.3 The manufacturer should state any other limitations on bucket size that apply to particular machines and, when requested, to particular operations.

7.43 DRAGLINE RATING CHART
A load rating chart shall be located on the machine, available to the operator from his position at the control stand. It shall include:
Rated dragline loads for recommended boom lengths at recommended radii.

Basis of dragline rating; firm, level, and uniform supporting surface (par. 7.02); rating percentage (par. 7.42); net load and practical working load definitions (par. 7.04[2]) and 7.04[3]).

Maximum weight of dragline bucket and contents (par. 7.42). Notes on the crane rating chart (Par. 7.14) satisfy this requirement.

7.44 DRAGLINE DATA
The manufacturer shall furnish the following data:
A. Data on dragline rating chart (see par. 7.43)
B. For hoist and drag drums:
   (1) Drum Pitch Diameter
   (2) Available Line Pull (see par. 4.02.4 and 6.03.1)
   (3) Available Line Speed (see par. 4.02.6 and 6.03.1)
7.45 DRAGLINE BUCKET CAPACITY RATING

The following formula has been established by the Bucket Manufacturers Bureau of the Construction Industry Manufacturers Association.

All dimensions are taken on the inside of a bucket and are expressed in inches.

\[ Wa = \text{Average inside width.} \]
\[ Wa = \frac{Wb + Wc + Wd + We}{4} \]

\[ Ha = \text{Average inside height.} \]

\[ L = \text{Edge of cutting lip to inside of back.} \]

\[ Sc = \text{Struck Capacity.} \]

\[ Rc = \text{Rated Capacity.} \]

Struck Capacity in Cubic feet = \[ \frac{Wa \times Ha \times L \times F}{1728} \]

F — represents a corrective factor expressing the loss of the capacity created by the adoption of the various curvatures by each manufacturer.

Rated Capacity in Cubic yards = \[ \frac{Sc \times 0.90}{27} = \frac{Sc}{30} \]

0.90 expresses a 10% loss of the struck capacity due to the angle of repose of the material.

Struck or rated capacities shall be within 2% of a specific size.

(2) 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 an 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.

(3) 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, drive the pile. It can be used to drive both plumb and batter piling.

(4) 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 (3) above 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 is usually required between the hoist line and the extractor is recommended to reduce the shock and vibration transmitted to the boom and machine.

7.51.2 Boom — See paragraph 7.01.

7.51.3 Pile Leads — These units include the following:

(1) 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.

(2) 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.

7.51.3.1 Pile Lead Attachment — The pile leads may be attached to the basic machine crane boom in several ways including:

(1) Free Swinging — Where the leads are suspended by one of the hoist cables.

(2) 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.
(3) 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.

7.51.4 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.

7.51.5 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.

7.51.6 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.

7.52 LOAD CAPACITY
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.

7.60 SHOVEL

7.61 SHOVEL EQUIPMENT
(See Fig. 4, Appendix A) Machines with shovel attachment are used to excavate hard or loose material in a bank or stock pile rising from the grade on which the shovel stands.

7.61.1 Shovel equipment includes a boom, a dipper stick mounted to pivot vertically about an axis on the boom and to “crowd” or “retract” in relation to this axis, a dipper attached to the dipper stick, a hoist rope operated by a drum on the revolving superstructure, machinery on the revolving superstructure to crowd and retract the dipper stick, and a dipper trip.

7.61.2 Crowd Mechanism — Crowding and retracting are defined as the outward and inward movements of the dipper stick in relation to its axis on the boom. There are three general types of crowd used on shovels. Manufacturer shall specify which one of the following is used:

(1) Combination Cable Crowd — A type having hoist drums and brakes, and requiring no special reversing mechanism.
(2) Independent or Positive Crowd — A type driven by either a cable or a chain, or a combination of both, from reversing mechanism on revolving superstructure.
(3) Dual Crowd — A type in which the reaction from dead end of hoist hitch is used to assist crowding of the dipper and where independent crowding mechanism is also provided.

7.61.3 Boom — A structural member, pivotally mounted on the revolving superstructure, supported by derricking ropes or other means.

7.61.4 Dipper Stick — A structural member to which the dipper is attached. Crowd and retract motions and forces may be transmitted to it through a pinion and rack drive, ropes or chains.

7.61.5 Dipper Trip — A power actuated unit for unlatching the dipper door to discharge the load.

7.62 SHOVEL DATA
The manufacturer shall furnish the following data

7.62.1 DIPPER CAPACITY (See par. 7.63)

7.62.2 ATTACHMENT DIMENSIONS (See Fig. 4, Appendix A, for dimensions)

7.62.3 FOR HOIST DRUM:
(1) Drum pitch diameter
(2) Available bail pull for number of parts in tackle (see par. 4.02.4 and 6.03.1)
(3) Available bail speed for numbers of parts in tackle (See par. 4.02.6 and 6.03.1).

7.63 SHOVEL DIPPER CAPACITY RATING
The following formula has been established by the Bucket Manufacturers Bureau of the Construction Industry Manufacturers Association.
The capacity of dippers is figured by multiplying the mean height of the dipper by the inside cross-sectional area of the dipper at one-half the minimum height.
All dimensions are taken on the inside of a dipper and are expressed in inches.
Capacity in Cubic Yards = \[
\frac{Area \times Ha}{46,656}
\]
Ha = The mean height = \[
\frac{A + B}{2}
\]
A = The maximum height from the most rearward point in a scopped leading edge of lip between the horns to the door. Does not include the teeth or horns.
B = The minimum height at the back of the dipper expressed in inches.
Area = Cross section of the dipper, established in square inches at one-half the minimum height \[
\frac{B}{2}
\]
46,656 = Cubic inches in a cubic yard.
A variation of 2% shall be allowed. If dipper is of special shape, proper allowance shall be made for the increased or decreased volume.

Figure 8.

7.70 HOE

7.71 HOE EQUIPMENT

(See Fig. 5, Appendix A) Machines with hoe attachments are used to excavate hard or loose material from below the grade on which the hoe stands.

7.71.1 Hoe equipment includes a boom, a dipper arm mounted to rotate vertically about an axis on the boom, a dipper attached to the dipper arm, and hoe mast.

7.71.2 Operating Mechanism:
Hoes may be operated by two ropes controlled by drums on the revolving superstructure. Dipper arm is pivoted at end of boom and dipper is fastened to arm. One hoist drum controls angle or position of boom which is live. One hoist drum controls angle of dipper arm and position of dipper, drags in dipper to load and releases it for dumping.

7.71.3 Boom — A structural member, pivotally mounted on the revolving superstructure.

7.71.4 Dipper Arm — A structural member pivoted on the boom, to which the dipper is attached.

7.72 RATED LOADS
Machines equipped with hoe attachments are sometimes used as cranes to place pipe in trenches they are excavating. When data are published on the ability of a hoe attachment to lift a load slung from the dipper, such load rating shall not exceed the lowest value established by the following three criteria:
A. 75% of the tipping load for either crawler or rubber tire carrier mountings.
B. Rope loading not exceeding a strength factor of 3.5 (See par. 7.13.1)
C. Maintaining a positive load in the digging rope.
Rated loads shall be based on the direction of minimum stability from the mounting, unless otherwise specified. No load shall be lifted over the front area of a truck mounted crane, except as approved by the crane manufacturer.

7.73 HOE DATA
The manufacturer shall furnish the following data.

7.73.1 DIPPER CAPACITY (See par. 7.74)

7.73.2 DIPPER WIDTH, INCLUDING SIDE CUTTERS IF FURNISHED.

7.73.3 ATTACHMENT DIMENSIONS (See Fig. 5, Appendix A, for dimensions)

7.73.4 FOR HOIST AND DIGGING DRUMS:
(1) Drum diameter
(2) Available ball pull for number of parts in tackle (See par. 4.02.4 and 6.03.1)
(3) Available ball speed for number of parts in tackle (See par. 4.02.6 and 6.03.1)

7.74 HOE DIPPER CAPACITY RATING
The following formula has been established by the Bucket Manufacturers Bureau of the Construction Industry Manufacturers Association.
All dimensions are taken on the inside of a dipper and are expressed in inches.
On the side view of the body, divide the view into 2" increments at the back end. The 2" increments are maintained for the length of the small curve. Where the bottom inside surface begins a more flat appearance, extending to the lip end between the teeth, divide that area into 4" increments.
The areas of the sections between these division lines are calculated and each area is multiplied by the average width of that section. The average width of the section is taken at a distance midway between the section lines. This is construed to compute struck measure, or line of plate.
The total of the figures is divided by 46,656 (cubic inches in a cubic yard) for the capacity in yards.
Nominal capacities will be indicated to the closest 1/4 yd. for dippers under one yard capacity and to the closest 1/4 yard for dippers in excess of one cubic yard capacity.

Figure 9.
SECTION 8
SAFETY REQUIREMENTS

8.0 GENERAL
The use of mobile cranes and excavators may involve certain hazards because they are subjected to an extremely wide variety of job applications and environmental conditions. For this reason it is impractical to produce a standard of safety requirements and recommendations which will cover all possible conditions encountered in the use of such equipment, and in itself provide complete assurance of safety. However this Standard does include extensive coverage on matters pertaining to safety, and if these rules are observed and supplemented by good job management and judgment, in dealing with conditions not specifically covered, satisfactory overall safety can be achieved. For additional information on safety practices refer to “ANSI Standard Safety Code for Crawler, Locomotive and Truck Cranes, ANSI B30.5.”

8.01 CARE & OPERATION MANUALS
Before operating or performing maintenance work, personnel should thoroughly study and understand all instructions found in manuals provided by the manufacturer, for the machine involved.

8.02 CLASSIFICATION OF SAFETY REQUIREMENTS
The degree of safety which can be expected in the use of mobile cranes and excavators is dependent upon the degree of adherence to good safety practice in each of the following separate areas of activity and responsibility.

8.1 Machine Construction and Characteristics.

8.2 Machine Inspection and Maintenance.

8.3 Machine Application and Operation.

8.1 MACHINE CONSTRUCTION & CHARACTERISTICS
This area of safety pertains to the physical capability and construction features of machines in relation to safe performance of specific work intended under conditions stipulated by the machine manufacturer. Since the general purpose and requirements of the previous sections deal principally with capability and construction features of Power Cranes and Excavators, safety requirements in this area are given particular emphasis. Many of these safety requirements are found in various other sections of the Standard for the reason that they are closely related to other subject matter in these sections. In such instances they also are made a part of this Sub-Section by paragraph references herein. Compliance with the safety requirements in 8.1 is the responsibility of the machine manufacturer.

8.1.1 Rated Capacities
8.1.1.1 Lifting Crane (See par. 7.12.1)
8.1.1.2 Clamshell Crane (See par. 7.22)
8.1.1.3 Magnet Crane (See par. 7.32)
8.1.1.4 Dragline (See par. 7.42)
8.1.1.5 Pile Driver (See par. 7.52)
8.1.2 Rating Charts
8.1.2.1 Lifting Crane (See par. 7.14)
8.1.2.2 Clamshell Crane (See par. 7.24)
8.1.2.3 Magnet Crane (See par. 7.34)
8.1.2.4 Dragline (See par. 7.43)
8.1.3 Backward Stability (See par. 7.03)
8.1.4 Main Drums (See par. 4.02)
8.1.4.1 Rope Capacity — The drums shall have sufficient rope capacity with recommended rope size and reeving to perform front end attachment functions within the range of boom lengths, operating radii and load travel distances stipulated by the manufacturer.
8.1.4.2 Rope Reserve — No less than two full wraps of rope shall remain on the drums with loads or front end attachment in extreme positions stipulated by the manufacturer.
8.1.4.3 Adjustments — Brakes & clutches shall be provided with adjustments where necessary to compensate for wear and to assure proper performance of these components.
8.1.5 Boom Hoist (See par. 4.03)
8.1.5.1 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.
8.1.5.2 Rope Reserve — 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.
8.1.11.2 Engine Exhaust — Exhaust gases from internal combustion engines shall be piped to the outside of the machinery cab and directed away from the machine operator. All exhaust pipes shall be insulated or guarded in areas where they may be contacted by personnel in the performance of their normal duties.

8.1.11.3 Outriggers — Means shall be provided to hold outriggers in both the retracted and extended positions. Floats, if provided, shall be attached to outriggers when in use.

8.1.11.4 Safety Guards — Insofar as practicable all moving machinery parts exposed to contact by personnel while following normal and proper operating and maintenance procedure shall be provided with suitable guards.

8.1.11.5 Sheave Guards — Sheaves carrying ropes which can momentarily be unloaded shall be provided with close fitting guards to guide the rope back into the groove when the load is again applied.

8.1.11.6 Clutch & Brake Protection — Friction type brakes and clutches should be protected from weather insofar as practicable.

8.1.11.7 Lubrication — Lubricating fittings should be located in as easily accessible positions as possible.

8.1.11.8 Boom Angle Indicator (See par. 7.11.2)

8.1.11.9 If a magnet is furnished by the manufacturer, energizing current should be of sufficient capacity and uniformity to minimize dropping portions of the load while swinging.

8.2 MACHINE INSPECTION AND MAINTENANCE

This area of safety pertains to inspection, servicing and maintenance which are extremely important in the safe use of power cranes and excavators. Many critical components on the machines are subject to wear and other deterioration or damage which limit their useful life; thus, they are expendable. When new, all such parts have a built-in reserve strength against unknown conditions and reasonable loss of strength due to gradual deterioration. However if replacement is neglected, these parts can eventually reach a condition where they become a safety hazard. Failure to maintain correct adjustments of the various mechanisms to assure proper performance of the machine also can be a safety hazard. Since the machine manufacturer has no direct control over the field inspection and maintenance, safety in this area is the responsibility of the user.

8.2.1 Inspection — All machines in active service should be inspected at regular intervals for proper adjustment of operating mechanisms, excessive wear or deterioration of components, accidental damage and any other defects which might be questionable as to safety. Any deficiencies noted should be carefully investigated and determination made as to whether they constitute a safety hazard. Inspection is vital to safe operation. It should be performed by competent personnel and on a regular and systematic basis.
8.2.1.1 Inspection Frequency — Frequency requirements of inspection depend upon numerous factors such as machine activity, severity of service, vulnerability of parts to wear and damage and the extent to which parts may be deemed critical in relation to safety. Inspection frequency can be divided into two general categories as follows:

(1) Daily to monthly intervals including observation during operation for any defects which might appear between regular inspections. Items such as all functional operating mechanisms, rope, rope reeving, sheaves, drums, brakes, locking and safety devices, hooks, boom, jib, etc. should be included in this category.

(2) One to twelve month intervals. A complete machine inspection including items as in 1 above and in addition the machine basic structure, gearing, shafting bearings, power plant, chain drives, electrical equipment, etc.

8.2.1.2 Wire Rope Inspection — All wire ropes in active service should be visually inspected once every working day. A thorough inspection of such ropes should be made at least once a month and dated records kept as to rope condition. Any deterioration, resulting in appreciable loss of original strength should be carefully examined and determination made as to whether further use of the rope would constitute a safety hazard. Conditions such as the following should be sufficient reason for questioning rope safety and for consideration of replacement.

(1) Corrosion.

(2) More than one broken wire in any one strand. Breaks occurring on crowns of outside wires indicate normal deterioration. Breaks in valleys between strand indicate an abnormal condition, possibly fatigue or breakage of other wires not readily visible.

(3) More than one broken wire near attached fittings.

(4) Heavy wear and/or broken wires in rope sections under sheaves where rope travel is limited or at points of contact with saddles.

(5) Evidence of appreciable reduction in original rope diameter after allowance for normal stretch and diameter reduction of newly installed rope.

(6) Extensive abrasion, scrubbing and peening of outside wires, pitting, kink damage or other mechanical abuse causing distortion of rope structure.

(7) Sheaves, guards, guides, drums, flanges, and other surfaces contacted by the rope during operation should be inspected for conditions which are harmful to the rope.


8.2.2 Maintenance — Preventive maintenance programs based on the manufacturer’s recommendations should be established. However, due to the wide variation in job applications, severity of service, machine activity and environment it is impossible for the manufacturer to develop a single, complete standard procedure which will fit all applications. Therefore such programs should be developed by trained and experienced personnel, responsible for maintenance of the machine, by adjustment and extension of the manufacturer’s general recommendations, to suit the particular needs.

8.2.2.2 Replacement Parts — It is recommended that all replacement parts be obtained from the original equipment manufacturer in order that the strength and quality of the original machine may be maintained.

8.2.2.3 Wire Rope Replacement — A fully comprehensive and precise set of rules cannot be given for determination of exact time for rope replacement since many variable factors are involved. Safety in this respect depends largely upon the use of good judgment by competent maintenance personnel in evaluating remaining rope strength in a used rope after allowance for deterioration disclosed by inspection. However, any of the following listed conditions should be cause for rope replacement.

(1) In running ropes, six randomly distributed broken wires in one rope lay, or three broken wires in one strand in one rope lay. (A rope lay is the length along the rope in which one strand makes a complete revolution around the rope.)

(2) In pendants or standing ropes, evidence of more than one broken wire in one lay.

(3) Abrasion, scrubbing, or peening causing loss of more than $\frac{1}{2}$ of the original diameter of the outside wires.

(4) Evidence of severe corrosion.

(5) Severe kinking, severe crushing, or other damage resulting in distortion of the rope structure.

(6) Evidence of any heat damage from a torch or arc caused by contact with electrical wires.

(7) Reduction from nominal rope diameter of more than $\frac{3}{4}$" for diameters up to and including $\frac{3}{4}$"; $\frac{1}{4}$" for diameters $\frac{3}{4}$" to $1\frac{3}{8}$"; $\frac{1}{2}$" for diameters $1\frac{1}{4}$" to $1\frac{3}{8}$". Marked reduction in diameter indicates deterioration of the core, resulting in lack of proper support for the load carrying strands. Excessive rope stretch or elongation may also be an indication of internal deterioration.

(8) Evidence of “bird caging” or other distortion resulting in some members of the rope structure carrying more load than others.

(9) Noticeable rusting or development of broken wires in the vicinity of attachments. (Note: If this condition is localized in an operating rope and the section in question can be eliminated by making a new attachment, this can be done rather than replacing the entire rope.

8.2.2.4 All rope should be of proper size, grade and construction for the particular function it is to perform on the machine.

8.2.2.5 Lubrication — Regular and systematic lubrication should be maintained on the machine, in accordance with the manufacturer’s lubrication charts and general recommendations. All machinery should be stopped while lubricating except in cases where the lubricating system is designed for safe application while the machinery is in motion. Any guards or panels which must be removed for access to some points for lubrication or inspection should always be replaced before resuming operation.

8.2.2.6 Maintenance Tools — Routine maintenance tools should be available at all times.

8.2.2.7 Fire Extinguisher — A carbon-dioxide or dry chemical hand fire extinguisher should be kept in the crane cab at all times.

8.3 APPLICATION AND OPERATION

8.3.1 General — This is probably the most important area relative to safety since it involves the greatest frequency of exposure to hazards. The operator should be fully competent physically, mentally and emotionally to understand and apply established operating safety rules. He should be able to exercise good judgment in dealing with the many situations which cannot be anticipated and covered herein. Since the manufacturer has no direct control over machine application and operation, conformance with good safety practice in this area is the responsibility of the user or his operating personnel.

8.3.2 Application — Only machines of proper rated capacity and type should be assigned to the job to be done. Anything less constitutes a safety hazard.

8.3.3 Operation — In general, established operating safety rules where applicable should be observed in performing all operating functions. Operating safety rules are found in sources such as the following:

B. Power Crane and Shovel Association — “125 Ways to Better Power Shovel — Crane Operation.”
C. Manufacturer’s Care and Operation Manuals.

It is recognized that written rules cannot cover all situations which might be encountered on the job. To meet such unanticipated situations the operator must be able to supplement his own rules based on good judgment.

8.3.3.1 Capacity Ratings — Manufacturers’ ratings should never be exceeded. The stipulations pertinent to these ratings should always be carefully observed. Under some conditions even the full standard capacity ratings cannot be recommended and must be adjusted downward to compensate for special hazards. (See “Practical Working Loads” par. 7.04[3]).

8.3.3.2 Ratings Based on Structural Competence — As the shorter rated radii is approached in lifting crane operation the load required to tip the crane increases very rapidly to a point where the actual tipping load is almost unlimited. Rated loads based on excessive tipping loads cannot be covered by adequate design factors since this would result in excessive machine weight and limitation of the machine’s usefulness. Consequently, some of the ratings shown on the chart may be based on machine strength rather than stability, in which cases the full use of stability in lifting loads is not intended or approved. It is therefore unsafe to apply any load which is greater than the rated load shown on the chart for that radius. (See par. 7.04[1]).

8.3.3.3 Counterweight — The maximum counterweight approved by the manufacturer for use on a given machine should never be exceeded. Unauthorized addition of counterweight in the field to increase lifting ability constitutes a safety hazard in two ways. First the added lifting ability and higher loading of machine parts have not been taken into account in the design. Second the backward stability margin built into the machine (see par. 7.03) for the user’s protector could be reduced beyond that considered safe practice.

8.3.3.4 Level Machine — All ratings are based on levelness of the machine in both directions. Any deviation from this condition introduces a safety hazard, the degree of which depends upon the amount of deviation, and must be taken into account by the operator in loading and handling the machine.

8.3.3.5 Stationary Machine — All ratings are based on non-use of the travel function while handling loads. Travel with suspended loads involves so many variables such as ground conditions, boom length, side, forward and rearward swinging of the load, momentum in starting and stopping, etc. that it is impossible to devise a single standard rating procedure with any assurance of safety. If such an operation is attempted the user must evaluate the local conditions and determine safe procedure.

8.3.3.6 Freely Suspended Loads — All crane ratings are based on this condition and do not include allowance for the excessive side loads which could be developed in attempting to drag rated loads not free to swing. Safety in any side dragging operation is entirely dependent upon the user’s judgment in making proper allowances.

8.3.3.7 Rigging of Booms — Booms which are being assembled or disassembled on the ground with or without support of the boom harness should be securely blocked up to prevent dropping and injury to ground personnel.

8.3.3.8 Unattended Machines — Before leaving his control station the operator should land any suspended working load, place such controls in neutral position and set all locking and safety devices as necessary to safely secure the machine.

8.3.3.9 Ground or Support Conditions — Capacity ratings are based on the condition of a firm supporting surface under the machine. Operating personnel should consider and allow for unusual conditions, since yielding of the supporting surface during operation may be a safety hazard.

8.3.3.10 Operation Near Electric Power Lines — Consult references listed in paragraph 8.3.3, or possible local codes.

8.3.3.11 Hand Signals — See ANSI Standard Safety Code for Crawler, Locomotive and Truck Cranes, ANSI B30.5 (this portion reproduced in Appendix H).

8.3.3.12 Gantry or Mast — Where gantry or mast heights on a machine can be varied, the manufacturers’ recommendations as to proper height and equipment for specified operating conditions should always be carefully followed.

8.3.3.13 Suspended Loads — the operator should remain at his control station ready for emergency action at all times while any suspended load is held by locked brakes or other locking means.

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SECTION 9
GLOSSARY

9.0 The following is a glossary of technical terms and definitions peculiar to the power crane and shovel industry. No terms of a general mechanical engineering or design nature are listed.

ACCESSORY. A secondary part or assembly of parts which contributes to the overall function and usefulness of a machine.

A-FRAME. See “GANTRY” 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. An alternate designation for front end equipment. Also, any other device that may be added as a complete unit or assembly.

AXIS OF ROTATION. The vertical line through the axis around which the crane superstructure rotates.

AXLE. The shaft or spindle about which a wheel revolves. On truck and wheel mounted cranes it refers to an automotive type of axle assembly including housings, gearing, differential, bearings and mounting appurtenances.

AXLE (BOGIE). Two or more automotive type axles mounted in a frame so as to distribute the load between the axles and permit vertical oscillation of the wheels.

BACKFILLER. Machine used for refilling a trench or excavation. The term is applied to various machines equipped as shovel, hoe, clamshell, or dragline, and also to a small dragline with a backfiller board having chains or bridles for connection to hoist and dragline cables.

BACK HITCH GANTRY. A structural frame, located to the rear of the revolving superstructure and usually extending above the cab. Retractable means are usually available to lower to cab height for roadable convenience. Its purpose is to support the boom hoist derrickng system.

BACK HOE. See “HOE.”

BACKWARD STABILITY. Resistance to overturning of the machine in rearward direction, thereby prohibiting excessive counterweighting for a given attachment.

BAIL (BUCKET OR DIPPER). A yoke or spreader hinged to sides of shovel dipper, hoe dipper, or dragline bucket to which is attached connecting sheave or chain for hoisting and dragging operations.

BAIL BLOCK. Block attached to shovel or hoe dipper, 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.

BALLAST. See “COUNTERWEIGHT.”

BAND BRAKE. Circular type of brake either of external contracting type or internal expanding type, having a strap lined with heat and wear resistant friction material.

BAND CLUTCH. Circular type of clutch either of external contracting type or internal expanding type, having a strap lined with heat and wear resistant friction material.

BARREL. The lagging or body portion of a rope drum.

BASE (MOUNTING.) The traveling base upon which the revolving superstructure is mounted, such as a car, truck, crawler or wheel platform.

BASE (ROTATING). See “REVOLVING SUPERSTRUCTURE.”

BASE (TURNTABLE). See “REVOLVING SUPERSTRUCTURE.”

BOGIE AXLE. See “AXLE (BOGIE).”

BOOM. A member hinged to the revolving superstructure and used as a part of an attachment.

BOOM ANGLE. The angle above horizontal of the straight line joining the centerline of the boom foot pin and centerline of the boom point load hoist sheave pin.

BOOM CHORD. A main corner member of a lattice type boom.

BOOM HOIST. Rope drum(s) and its drive, or other mechanism 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. The straight line distance from centerline of boom foot pin to centerline of boom point load hoist sheave pin.
BOOM SECTIONS. Crane booms are usually in two sections, upper and lower. Such booms may be lengthened by insertion of one or more additional sections.

BOOM SPLICES. Splicing connections for sections of basic crane boom and additional sections usually of the splice plate type, pin type or butt type.

BOOM STOP. A device used to limit the angle of the boom to the highest recommended boom angle.

BOOSTER. An auxiliary device attached to main functional clutch or brake to activate it for greater ease of operation. Also separate auxiliary device used to assist in other functions such as steering.

BRAKE. A device for retarding or stopping motion by friction or power means.

BRAKE SHOE. That part of a shoe-type brake or clutch which makes contact with brake drum or clutch drum.

BRIDLE. See "FLOATING HARNESS."

BUCKET. See "CONCRETE, CLAMSHELL AND DRAGLINE BUCKET."
A material container attached to machine by flexible means, such as wire rope.

BULL GEAR. See "SWING GEAR."

CAB. A housing which covers the revolving superstructure machinery and operators station. On truck crane trucks a separate cab to cover the drivers station.

CABLE. A flexible electrical conductor.

CAR BODY. See "BASE MOUNTING."

CENTER PIN. Vertical pin or shaft which acts as rotation centering device and connects revolving superstructure and base mounting.

CENTER PINTLE. See "CENTER PIN."

CENTER POST. See "CENTER PIN."

CHAIN CROWD. A crowd mechanism on a shovel attachment driven by a chain.

CLAMSHELL. See Par. 7.21.

CLAMSHELL BUCKET. A bucket used with the clamshell attachment.

CLOSING LINE. The rope reeved from hoist drum to control closing of clamshell bucket.

CLUTCH. A friction, electromagnetic, hydraulic, pneumatic or mechanical locking device for engagement or disengagement of power.

COMBINATION CROWD. A crowd mechanism on a shovel attachment having hoist drums and brakes and requiring no special reverse mechanism.

CONCRETE BUCKET. Bucket for handling wet concrete, fitted with bail or bridle, usually handled on lifting crane and hoisted to dumping location.

CONVERTIBILITY. Ability of machine to be equipped for different types of work through interchangeability of front end equipment.

COUNTERWEIGHT. Weight used to supplement the weight of the machine in providing stability for lifting working loads and usually attached to rear of revolving superstructure. Also called "BALLAST."

CRAWLER BELT. Assembled crawler tread shoes and connecting pins around rollers and drive sprockets; that part of crawler which contacts the ground.

CRAWLER BEARING LENGTH. See Par. 5.02.

CRAWLER CHAIN. Chain used as final drive to the crawler belt.

CRAWLER FRAME. See "CRAWLER MOUNTING."

CRAWLER MOUNTING. See Par. 5.01.

CRAWLER SHOES. See "TREAD SHOES."

CROSSOVER. See "FLOATING HARNESS."

CROWD. Outward movement of the dipper stick in relation to its axis on the boom.

CUSHION BLOCK. Wood or plastic material positioned between the pile driving hammer and pile cap to reduce impact damage.

CUTTING LIP. The edge of a bucket or dipper which penetrates material to be excavated. Teeth may or may not be attached.

CUTTING WIDTH. Actual width of opening cut by a bucket or dipper measured by overall width of outside teeth, cutters, or side plates.

DERRICKING. Operation of changing boom angle in a vertical plane. See "BOOM HOIST."

DIPPER. See "SHOVEL DIPPER" and "HOE DIPPER." A material container rigidly attached to machine.

DIPPER ARM. See Par. 7.71.4.
DIPPER HANDLE. See "DIPPER STICK."

DIPPER LATCH. A mechanism which holds dipper door shut and can be tripped for dumping.

DIPPER LATCH BAR. Bar attached to dipper door, fitting into latch plate on dipper, actuated by dipper trip mechanism, for opening and closing door for dumping.

DIPPER STICK. See Par. 7.61.4.

DIPPER TRIP. See Par. 7.61.5.

DRAG ROPE. Rope for pulling in bucket in dragline or hoe operations.

DRAGLINE. See Par. 7.41.

DRAGLINE BUCKET. A bucket used with the dragline attachment.

DRAGLINE FAIRLEAD. See Par. 7.41.3.

DRAG SHOVEL. Another term for "HOE."

DRIVE TUMBLER. Roller with teeth or lugs which contact matching recesses or lugs or pins in crawler belt.

DROP HAMMER. See Par. 7.51.1.

DRUM (ROPE). A rotating cylinder with side flanges on which rope used in machine operation is wrapped.

DUAL CROWD. See Par. 7.61.2.

EXCAVATOR. A term used for any machine which digs material.

FAIRLEAD. A device to guide wire rope for proper spooling.

FLOATING HARNESS. A frame equipped with sheaves and connected to the boom by stationary ropes usually called pendants.

FUEL PUMP (HAND). Hand-operated pump used for filling fuel tank by pumping fuel from another receptacle.

FULL-LOAD SPEED. Revolutions per minute of power plant at rated power.

GANTRY (A-FRAME). See Par. 4.05.

GOOSENECK BOOM. A boom which has an integral upper section projecting at an angle from longitudinal axis of lower section.

GOVERNED SPEED. Engine revolutions per minute controlled by the power plant governor.

GRADEABILITY. The slope which a machine can climb expressed as a percentage.

GROUND PRESSURE. Weight of machine divided by the area of the surface directly supporting the machine.

GROUSER. Projecting lugs attached to, or integral with, crawler tread 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. 7.51.1.

HAMMER HEAD BOOM. A boom on which both hoist and boom suspension lines are offset from centerline of boom for load clearance.

HOE. See Par. 7.71.1.

HOE MAST. See "MAST."

HOIST. The process of lifting.

HOLDING LINE. The cable reeved from second 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.

HOOK ROLLERS. Rollers which prevent the lifting of the turntable from the base.

IDLER ROLLER. Rollers of tread belt mechanism which are not power driven.

IDLER TUMBLER. Large end roller of crawler belt mechanism at opposite end from drive tumbler and which is not power driven.

INDEPENDENT CROWD. See Par. 7.61.2.

INDEPENDENT BOOM HOIST, SWING, AND TRAVEL. A drive independent of all other functions.

JACK SHAFT. Term applied to an intermediate shaft.

JIB. See Par. 7.11.6.

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 angular or tubular lacing between main corner members in form of truss.

LIFTING CAPACITY. See Par. 7.04.

LINE PULL. The rope pull generated off a rope drum or lagging at a specified pitch diameter.

LINE SPEED. The rope velocity at a rope drum or lagging at a specified pitch diameter.

LIVE ROLLER CIRCLE. An assembly of multiple swing rollers free to roll between revolving superstructure and mounting.

LOAD (WORKING). See Par. 7.04.

LOAD BLOCK. See "HOOK BLOCK."

LOAD 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. 4.02.3.

LOAD RATINGS. See Par. 7.04.

LUFFING. See "DERRICKING."

MAGNET. See Par. 7.31.

MAGNET CONTROLLER. Electric controller for governing flow of current to magnet. Part of magnet equipment.

MAIN DRUMS. See Par. 4.02.

MAST. Frame 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. Supports or floats used for supporting machine on soft ground. Usually of timber construction.

NET LOAD. See Par. 7.04.

OUTRIGGERS. Extendible arms attached to the mounting base, which rest on supports at the outer ends to increase stability.

OVERHAUL. Ability of a weight on end of hoist line to unwind cable from drum when brake is released.

PADLOCK. A sheave and its housing by which the hoist line is connected to the dipper either directly or through a bail. See also "BAIL BLOCK."

PAY LOAD. See "NET LOAD."

PENDANT. Another term for "GUY ROPE."

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 PLANT. See Par. 3.01.3.

POWER CONTROLLED LOWERING. See Par. 4.02.3.

PRIME_MOVER. See Par. 6.02.

POWER TAKEOFF. See Par. 6.03.

PULL BLOCK. See "BAIL BLOCK."

PULL SHOVEL. Another term for hoe. Also see Par. 7.71.1.

RACK. A gear-toothed surface on dipper stick which meshes with shipper shaft pinion; a flat gear.

RACKING. Operation of crowding or retracting dipper.

RADIUS (OF LOAD). See Par. 7.02.2.

RATED LOAD. See Par. 7.04 (1).

REAR END RADIUS. Clearance distance from center of rotation to maximum rear extension of revolving superstructure. Also called "TAIL SWING."

REEVING. A rope system where the rope travels around drums and sheaves.

REMOTE CONTROL. See Par. 5.19.

REVOLVING SUPERSTRUCTURE. See Par. 4.01.

RING GEAR. See "SWING GEAR."

ROLLER PATH. The surface upon which run the rollers that support revolving superstructure. It may accommodate either cone rollers, cylindrical rollers, or live rollers.

ROPE. Refers to wire rope unless otherwise specified. See "WIRE ROPE."

ROTATING BASE. See "REVOLVING SUPERSTRUCTURE."
SADDLE BLOCK. Mechanism and bearings which carry shipper shaft drive and acts as guide for dipper stick.

SHIPPER SHAFT. Shaft near center of shovel boom which acts as pivot point of dipper stick as its angle and thrust positions are changed and on which is mounted the dipper stick crowding and retracting mechanism of the boom.

SHOES. See “TREAD SHOES.”

SIDE LOADING. A load applied at an angle to the vertical plane of the boom.

SLEWING. See “SWING.”

SPREADER BAR. See “FLOATING HARNESS.”

STABILITY. The ability of a mobile machine to resist tipping. Does not normally apply to a stationary mounting. Also see Par. 7.03.

STEAM HAMMER. Steam driven pile hammer.

STRIPPER. Machine used for excavating overburden in open cut mining. The term is usually applied to a shovel or dragline modified or designed for greater reach than the manufacturers rating for the particular standard size of machine. A stripping shovel may be equipped with extra long boom and dipper stick and with a dipper smaller than the nominal rated capacity. Also referred to as a high-lift shovel. 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 applied loads.

SUPERSTRUCTURE. See “REVOLVING SUPERSTRUCTURE.”

SWAY BRACES. Stiffening ropes or rods with or without turnbuckles, sometimes used on each side of boom.

SWING. See Par. 4.04.

SWING BEARING. A combination of rings with balls or rollers capable of sustaining radial, axial, or overturning loads of the revolving superstructure.

SWING BRAKE. See Par. 4.04.2.

SWING CIRCLE. See “SWING BEARING.”

SWING GEAR. External or internal gear with which swing pinion on revolving superstructure meshes to provide swing motion.

SWING LOCK. See Par. 4.04.2.

SWING MECHANISM. The machinery involved in providing dual directional rotation of the revolving superstructure.

SWING SPEED. See Par. 4.04.1.

TACKLE (HOIST). Assembly of ropes and sheaves arranged for pulling.

TAGLINE. See Par. 7.21.4.

TAIL SWING. See “REAR END RADIUS.”

THIRD DRUM. A third hoist drum, in addition to two main hoist drums, often used in pile driving.

TIPPING CONDITION. See Par. 7.02.

TIPPING LOAD. See Par. 7.02.3.

TIRE SIZES. These are specified by diameter of casing, diameter of wheel and ply rating, i.e., 9.00 x 20-10 ply is a 9 inch diameter casing on a 20 inch diameter wheel or rim, and is of 10 ply construction.

TOOTH BASE. Main part of bucket or dipper tooth to which removable tooth points are fastened.

TOOTH POINTS. Removable and replaceable points for dipper or bucket teeth.

TORQUE CONVERTER. Auxiliary hydraulic device connected to prime mover which multiplies engine torque as load increases with a corresponding decrease in speed.

TOWER ATTACHMENT. A crane attachment usually adaptable to a basic crane machine. The attachment consists of a vertical tower with a working boom affixed to the upper part of tower.

TRACK. See “CRAWLER BELT.”

TRAVEL. The function of the machine moving from one location to another.

TRAVEL MECHANISM. The machinery involved in providing travel.

TREAD BELT. See “CRAWLER BELT.”

TREAD SHOES. Hinged steel pads joined to form a continuous crawler belt which supports the machine.

TRENCH HOE. Another term for hoe.

TRUCK CRANE. Crane mounted on independent engine-driven rubber-tire carrier.

TUMBLER. One of the large rollers for a crawler belt. See “IDLER TUMBLER” and “DRIVE TUMBLER.”

TURNING CIRCLE. See Figure 1, Appendix A.

TURNTABLE. See “REVOLVING SUPERSTRUCTURE.”

WHIP LINE. Secondary hoist line. Also see “LOAD 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 bent.

WORKING WEIGHT. Weight of machine in working order with complete front end equipment.
APPENDICES
APPENDIX A

(REPRODUCED FROM 1967 SAE HANDBOOK BY PERMISSION OF SOCIETY OF AUTOMOTIVE ENGINEERS, INC.)

NOMENCLATURE AND DIMENSIONS FOR CRANE SHOVELS—SAE J958

SAE STANDARD


This SAE Standard includes names of major components and parts peculiar to this type equipment. Illustrations are not intended to show all existing commercial machines or to be exactly descriptive of any particular machine. They have been selected to depict principles used in identifying specific mechanism and to identify useful dimensional relationships.

FIG. 1

NOTE: Refer to SAE J695.

DIMENSIONS

For revolving superstructure dimensions, see Fig. 3 (A-P).

P DISTANCE FROM CENTER OF REAR AXLE OR BOGIE TO AXIS OF ROTATION.

Q DISTANCE BETWEEN CENTERS OF AXLES OF TANDEM AXLE BOGIE.

R WHEELBASE (WHEELBASE FOR TANDEM FRONT AXLE IS MEASURED TO TANDEM CENTER PIVOT POINT).

S DISTANCE FROM CENTER OF REAR AXLE OR BOGIE TO REAR END OF FRAME.

T OVERALL LENGTH OF CARRIER.

U1 MAXIMUM OVERALL WIDTH WITH RETRACTED OUTRIGGERS (FLOATS REMOVED).

U2 MAX. OVERALL WIDTH WITH RETRACTED OUTRIGGERS (FLOATS ATTACHED).

V1 TRACK OR TREAD WIDTH, REAR AXLE.

V2 TRACK OR TREAD WIDTH, FRONT AXLE.

W EFFECTIVE LENGTH OF EXTENDED OUTRIGGERS.

X OVERALL WIDTH OVER FLOATS WITH OUTRIGGERS EXTENDED.

Y DISTANCE FROM BACK OF CARRIER CAB TO CENTER OF REAR AXLE OR BOGIE (KNOWN AS CA DISTANCE IN TRUCKING INDUSTRY).

TRUCK TYPE MOUNTING (6x4 OR 6x6 SHOWN)

FIG. 2—RUBBER TIRE CARRIER MOUNTINGS WITH REVOLVING SUPERSTRUCTURE

DEFINITIONS

For revolving superstructure definitions, see Fig. 3 (Q-2).

1. FRONT END ATTACHMENT

2. REAR AXLE OR BOGIE.

3. FRONT OUTRIGGER BOX.

4. REAR AXLE OR REAR TANDEM BOGIE.

5. REAR OUTRIGGER BOX.

6. OUTRIGGER BEAM.

7. OUTRIGGER JACK.

8. OUTRIGGER FLOAT.

9. SWING CIRCLE OR ROLLER PATH.

10. AXES OF ROTATION.

11. SELF-PROPELLED MOUNTING (4x2 OR 4x4 SHOWN)
FIG. 3—CRAWLER MOUNTING WITH REVOLVING SUPERSTRUCTURE (See Appendix B)

NOTE: For ground clearance dimensions see SAE J894.

FIG. 4—SHOVEL ATTACHMENT

DIMENSIONS
A BOOM LENGTH FROM BOOM FOOT PIN TO BOOM HEAD SHEAVE PIN
B EFFECTIVE TRAVEL LENGTH OF DIPPER STICK
C MAXIMUM DUMPING HEIGHT
D DUMPING RADIUS (CENTER OF FLOW FROM DIPPER) AT MAXIMUM HEIGHT
E MAXIMUM DUMPING RADIUS (CENTER OF FLOW FROM DIPPER)
F MAXIMUM CUTTING HEIGHT
G MAXIMUM CLEAN-UP RADIUS AT FLOOR LEVEL
H MAXIMUM DIGGING DEPTH BELOW FLOOR LEVEL
I MAXIMUM CUTTING RADIUS
J BOOM HEAD CLEARANCE HEIGHT
K BOOM HEAD CLEARANCE RADIUS
L DUMPING HEIGHT AT MAXIMUM DUMPING RADIUS

DEFINITIONS
1. DIPPER
2. DIPPER BAIL
3. DIPPER STICK
4. BOOM
5. SHIPPER SHAFT SADDLE
6. SHIPPER SHAFT
7. AXIS OF ROTATION

FIG. 5—HOE ATTACHMENT

DIMENSIONS
N BOOM LENGTH FROM BOOM FOOT PIN TO DIPPER ARM HINGE PIN
O SWEEP RADIUS FROM DIPPER ARM HINGE PIN TO DIPPER TOOTH POINT
P HEIGHT OF HOE MAST IN WORKING POSITION
Q MAXIMUM REACH AT GRADE LEVEL
R DIGGING DEPTH RATING (45 DEG BOOM ANGLE FOR RATING PURPOSES)
S RADIUS OF DIPPER TEETH AT BEGINNING OF DUMP
T1 CLEARANCE OF DIPPER FROM GROUND AT BEGINNING OF DUMP
T2 CLEARANCE OF DIPPER FROM GROUND AT THE LOW POINT OF THE DIPPER DUMP CLEARANCE
U CLEARANCE RADIUS AT END OF DUMP
V CLEARANCE FROM GRADE AT END OF DUMP
W OVERALL HEIGHT AT END OF DUMP

DEFINITIONS
7. HOE MAST
8. BOOM
9. DIPPER
10. DIPPER BRACE BAR
11. DIPPER ARM
12. AXIS OF ROTATION

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FIG. 6—COMMON CRANE BOOM EQUIPMENT

**DIMENSIONS**
- X: BOOM LENGTH FROM BOOM FOOT PIN TO BOOM HEAD SHEAVE PIN
- Y: JIB LENGTH FROM JIB FOOT PIN TO JIB HEAD SHEAVE PIN
- Z: RADIUS OF LOAD (ALSO APPLIES TO JIB HOOK LOAD)
- Z: BOOM ANGLE
- Z: OFFSET ANGLE OF JIB (ALSO CAN BE GIVEN AS AN OFFSET DIMENSION)

**DEFINITIONS**
- 12. DERRICKING OR LIVE BOOM MOIST HOIST ROPE
- 13. FLOATING HARNES OR BRIDLE
- 14. PENDANTS, GUYS OR BOOM BACKSTAYS
- 15. CRANE BOOM BACKSTAY LINES
- 16. JIB BACKSTAY LINES
- 17. JIB MAST
- 18. JIB FRONT STAY LINES
- 19. JIB
- 20. CONCRETE BUCKET
- 21. CLAMSHELL BUCKET
- 22. DRAULINE BUCKET
- 23. PILE DRIVER LEADS
- 24. MAGNET
- 25. GRAPPLE
- 26. MAIN LIFT HOOK BLOCK
- 27. MAIN MOIST LINE
- 28. JIB OR WHIPLINE HOOK
- 29. JIB OR AUXILIARY MOIST LINE
- 30. DRAULINE FAIRLEAD
- 31. TAGLINE WINDER OR MAG. NET TAKE-UP REEL
- 32. AXIS OF ROTATION

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This SAE Standard includes terminology common to the usage of construction and industrial machinery. All measurements of physical dimensions shall be made with the vehicle equipped and loaded on a level surface with zero surface penetration, unless otherwise specified. Vehicle and equipment are to be in normal position.

1. **Width**—The distance between the vertical planes perpendicular to the vehicle axis through the farthest points on the two sides of the vehicle.

2. **Length**—The distance between the vertical planes perpendicular to the vehicle axis through the farthest points on the front and rear of the vehicle.

3. **Height**—The vertical distance to a plane parallel to the ground through the highest point on the vehicle.

4. **Track Gage**—The distance from the center of the sprocket teeth on one side of the vehicle to the center of the sprocket teeth on the other side.

5. **Tread**—The distance between the left and right tire center lines of each axle of the vehicle. Center line for dual tires is midway between tire centers.

6. **Wheel Base**—The horizontal longitudinal distance from the center of the front wheel to the center of the rear wheel. For tandem axles the distance is measured to a line midway between the two axles.

7. **Angle of Approach**—(See Fig. 1.) The angle between the horizontal and a plane, tangent to the forward tires or tracks of a vehicle and passing through lowest point of any structure or component forward of the tires or tracks, which limits the magnitude of the angle.

8. **Inter-Axle Angle of Interference**—(See Fig. 1.) The maximum angle between two planes intersecting on a downward projection of the vehicle where the first plane is tangent to the tires ahead of the intersection and the second plane is tangent to the tires behind the intersection.

9. **Angle of Departure**—(See Fig. 1.) The angle between the hori-
TRUCK ABILITY
PREDICTION PROCEDURE—SAE J688

SAE Recommended Practice

INTRODUCTION—The procedure has been developed to provide a practical method for the prediction of truck performance using accepted data. It is designed to help anyone concerned with the problem of truck selection.

By following directions, it is possible to determine the necessary information for intelligent truck selection without being concerned with the origin or derivation of the complex factors involved. With readily available specifications of a truck, information provided in the tables, and a minimum of calculation, it is possible to predict:

(a) The performance obtainable from a truck of given characteristics under given operating conditions.

(b) The characteristics required in a truck to meet different performance requirements under given operating conditions.

This report comprises a procedure form and 10 tables of data. A complete explanation of the truck ability prediction procedure is contained in SAE Technical Report TR-82, Truck Ability Prediction Procedure. Part I of TR-82 contains, in addition to the procedure form and tables, work sheets and an example. Part 2 demonstrates by practical examples how to obtain some of the answers other than grade ability, and presents a detailed procedure for computing instantaneous acceleration and the time or distance required to accelerate between specified limits of speed. Part 3 gives terminology, the fundamental relations, and the formulas which form the basis for the procedure, a discussion of the reliability of factors and methods, and presents a method for evaluating the effect of wind on air resistance.

### TABLE 1—TIRE FACTOR

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Tire Factor = Loaded Radius

### TABLE 2—ALTITUDE FACTOR (FOR NET HP CORRECTION)

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<td>0.72</td>
<td>15,000</td>
<td>0.40</td>
</tr>
</tbody>
</table>

### PROCEDURE FORM FOR DETERMINING GRADE ABILITY AT A GIVEN ROAD SPEED AND EQUIVALENT ACCCELERATION RATE

**Data Pertaining to Vehicle and Conditions of Operation**

1. Vehicle identification [Make, model, and type of vehicle(s)]
2. Vehicle overall maximum dimensions (a) Height..................ft (b) Width..............ft
3. Total gross weight in thousand lb .....................
4. Manufacturer's maximum gross vehicle weight rating for power unit in pounds ...
5. Gear ratios (a) Transmission........... (b) Auxiliary transmission........ (c) Axle...
6. Total gear reduction..................
7. Net engine power at sea level (a) ..................hp at (b) .............rpm engine speed
8. Altitude ..................ft
9. Road surface type and condition ...........

**PROCEDURE**

<table>
<thead>
<tr>
<th>Steps</th>
<th>Procedure</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Apparent road speed in mph (^a)</td>
<td>(Item 7b) ((\text{Item 5d}) \times (\text{Tire factor}))</td>
</tr>
<tr>
<td>2.</td>
<td>Net engine hp corrected for altitude</td>
<td>(Altitude factor, Table 2) (\times (\text{Item 7a}))</td>
</tr>
<tr>
<td>3.</td>
<td>Rolling resistance hp</td>
<td>(Rolling factor, Table 3) (\times (\text{Item 3}))</td>
</tr>
<tr>
<td>4.</td>
<td>Air resistance hp</td>
<td>(Area factor, Table 4) (\times (\text{Velocity factor}) \times (\text{Altitude factor, Table 5}))</td>
</tr>
<tr>
<td>5.</td>
<td>Chassis friction hp</td>
<td>(Chassis factor, Table 7)</td>
</tr>
<tr>
<td>6.</td>
<td>Level road hp</td>
<td>Sum of values 3, 4, and 5</td>
</tr>
<tr>
<td>7.</td>
<td>Reserve hp(^b)</td>
<td>(Value 2) minus (Value 6)</td>
</tr>
<tr>
<td>8.</td>
<td>Grade resistance hp per 1000 lb weight</td>
<td>(Value 7) ((\text{Item 3}))</td>
</tr>
<tr>
<td>9.</td>
<td>Grade ability on C class road (good) (^c)</td>
<td>(Value 8) (\times (\text{Grade factor}))</td>
</tr>
<tr>
<td>10.</td>
<td>Grade deduction for road type and condition</td>
<td>(Road factor, Table 9)</td>
</tr>
<tr>
<td>11.</td>
<td>Net grade ability at apparent road speed (^d)</td>
<td>(Value 9) minus (Value 10)</td>
</tr>
<tr>
<td>12.</td>
<td>Approximate acceleration rate on level at apparent road speed in mph per sec (total gear reduction less than 10.0)</td>
<td>(0.2) (\times (\text{Value 11}))</td>
</tr>
</tbody>
</table>

\(^a\) Apparent road speed can be attained under given conditions only if sufficient net hp is available.

\(^b\) If this value is negative, the net hp is insufficient to attain apparent road speed.

\(^c\) Correct value using Table 8A if 20% or above.

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### TABLE 3—ROLLING FACTOR

<table>
<thead>
<tr>
<th>Speed (Mph)</th>
<th>Rolling Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.026</td>
</tr>
<tr>
<td>2</td>
<td>0.041</td>
</tr>
<tr>
<td>3</td>
<td>0.056</td>
</tr>
<tr>
<td>4</td>
<td>0.064</td>
</tr>
<tr>
<td>5</td>
<td>0.077</td>
</tr>
<tr>
<td>6</td>
<td>0.092</td>
</tr>
<tr>
<td>7</td>
<td>0.107</td>
</tr>
<tr>
<td>8</td>
<td>0.121</td>
</tr>
<tr>
<td>9</td>
<td>0.133</td>
</tr>
<tr>
<td>10</td>
<td>0.147</td>
</tr>
</tbody>
</table>

**Rolling Factor** = \((7.6 + 0.09 \text{ mph}) \times \text{mph}\)

### TABLE 4—AREA FACTOR

<table>
<thead>
<tr>
<th>Maximum Vehicle Height, ft</th>
<th>Area Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>(height - 0) % × width</td>
</tr>
</tbody>
</table>

**Area Factor** = \(\frac{375}{S}\)

### TABLE 5—VELOCITY FACTOR

<table>
<thead>
<tr>
<th>Speed (Mph)</th>
<th>Velocity Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.000</td>
</tr>
<tr>
<td>2</td>
<td>0.005</td>
</tr>
<tr>
<td>3</td>
<td>0.008</td>
</tr>
<tr>
<td>4</td>
<td>0.009</td>
</tr>
<tr>
<td>5</td>
<td>0.007</td>
</tr>
<tr>
<td>6</td>
<td>0.008</td>
</tr>
<tr>
<td>7</td>
<td>0.007</td>
</tr>
<tr>
<td>8</td>
<td>0.006</td>
</tr>
<tr>
<td>9</td>
<td>0.005</td>
</tr>
<tr>
<td>10</td>
<td>0.004</td>
</tr>
</tbody>
</table>

**Velocity Factor** = 0.002 (mph)'

### TABLE 7—CHASSIS FRICTION HORSEPOWER

<table>
<thead>
<tr>
<th>Manufacturer's Max Gross Vehicle Weight Rating of Power Unit</th>
<th>Engine Rpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>800</td>
<td>1000</td>
</tr>
<tr>
<td>1200</td>
<td>1400</td>
</tr>
<tr>
<td>1600</td>
<td>2000</td>
</tr>
<tr>
<td>2200</td>
<td>2600</td>
</tr>
<tr>
<td>3000</td>
<td>3400</td>
</tr>
</tbody>
</table>

### TABLE 8—GRADE FACTOR

<table>
<thead>
<tr>
<th>Grade Factor</th>
<th>Mph</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.5</td>
<td></td>
</tr>
</tbody>
</table>

**Grade Factor** = \(37.5\) mph

### TABLE 9—FACTOR

<table>
<thead>
<tr>
<th>Condition of Surface</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement concrete</td>
<td>0.0</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Brick</td>
<td>0.0</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Asphaltr block</td>
<td>0.0</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Granite block</td>
<td>0.0</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Steel armor</td>
<td>0.0</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Asphaltric concrete</td>
<td>0.0</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Bituminous macadam (high type)</td>
<td>0.0</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Wood block</td>
<td>0.0</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Bituminous macadam (low type)</td>
<td>0.0</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Bitumous (tar)</td>
<td>0.0</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Oil mast (laid macadam)</td>
<td>0.0</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Treated gravel</td>
<td>0.0</td>
<td>0.1</td>
<td>0.2</td>
</tr>
</tbody>
</table>

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CRANE SHOVEL BASIC OPERATING CONTROL ARRANGEMENTS — SAE J983 SAE Recommended Practice

Scope—This SAE Recommended Practice applies to mobile, construction type, crane shovel hand and foot controls. It should not be construed to limit the use of, or to apply to combination controls, automatic controls, or any other special operating control requirements.

General Notes—These general notes apply to all six of the control diagrams which cover specific applications of crane shovel machines.

1. The arrangement of the basic controls should be as shown in the application diagrams. Controls 1, 2, 3, and 4 are levers for hand operation; controls 5 and 6 are pedals for foot operation.

2. Controls for other functions, such as auxiliary drums and throttles, may be installed between or beside the basic controls, but such controls shall be positioned to avoid operator confusion and physical interference. Nothing in this recommended practice precludes the use of additional controls subject to the foregoing requirements.

3. The master clutch control shall be readily operable from the operator’s seat.

4. Controls 2, 3, 5, and 6 should be confined solely to the specified operating functions shown in the application control diagrams, except for shovel and backhoe application. Controls 1 and 4 may be temporarily converted from their specified operating function to operate noninstantaneous auxiliary functions (that is, travel controlled by swing control) provided that:

(a) In the specified application, all basic controls should operate as specified in the application control diagram.

(b) The disconnected function is restrained against unintended movement.

Independent controls for any and all basic and auxiliary operating functions are permissible.

5. All controls shall return to their released positions automatically upon operator release when not knuckled in.

CRANE CONTROL DIAGRAM
(Viewed from operator’s seat)

<table>
<thead>
<tr>
<th>Control</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Swing Control</td>
<td>Push forward to swing toward boom, swinging left for right side operator position or swinging right for left side operator position. Pull back to reverse these actions.</td>
</tr>
<tr>
<td>2. Hoist Control</td>
<td>Pull back to hoist. Center (released) to lower by brake 5. Push forward to lower, if provided with powered load lowering on this drum.</td>
</tr>
<tr>
<td>3. Hoist Control</td>
<td>Pull back to hoist. Center (released) to lower by brake 6. Push forward to lower, if provided with powered load lowering on this drum.</td>
</tr>
<tr>
<td>4. Boom Hoist</td>
<td>Pull back to raise boom. Center (released) to lower boom. Center (released) position must hold boom stationary even with boom safety panel released.</td>
</tr>
<tr>
<td>5. Hoist Brake</td>
<td>Push to hold or to stop lowering load. Release to lower load.</td>
</tr>
<tr>
<td>6. Hoist Brake</td>
<td>Push to hold or to stop lowering load. Release to lower load.</td>
</tr>
</tbody>
</table>

Notes:

BACK HOE CONTROL DIAGRAM
(Viewed from operator’s seat)

<table>
<thead>
<tr>
<th>Control</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Swing Control</td>
<td>Push forward to swing toward boom, swinging left for right side operator position or swinging right for left side operator position. Pull back to reverse these actions.</td>
</tr>
<tr>
<td>2. Inhaul Control</td>
<td>Pull back to drag in dipper. Center (release) to control by brake 5.</td>
</tr>
<tr>
<td>3. Hoist Control</td>
<td>Pull back to extend dipper. Center (release) to control by brake 6.</td>
</tr>
<tr>
<td>4. Inhaul Brake</td>
<td>Push to hold dipper. Release to extend dipper and when control 2 is engaged.</td>
</tr>
<tr>
<td>5. Hoist Brake</td>
<td>Push to hold dipper and extended. Release to lower dipper and when control 3 is engaged.</td>
</tr>
</tbody>
</table>

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### CRANE-SHOVEL BASIC OPERATING CONTROL ARRANGEMENTS

#### DRAGLINE CONTROL DIAGRAM
(Viewed from operator's seat)

<table>
<thead>
<tr>
<th>Control</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swing</td>
<td>Push forward to swing toward boom, swinging left for right side operator</td>
</tr>
<tr>
<td>Control</td>
<td>position or swinging right for left side operator position. Pull back to</td>
</tr>
<tr>
<td>Inhaul</td>
<td>reverse these actions.</td>
</tr>
<tr>
<td>Hoist</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>1. Swing Control</td>
<td>Push forward to swing toward boom, swinging left for right side operator</td>
</tr>
<tr>
<td>Control</td>
<td>position or swinging right for left side operator position. Pull back to</td>
</tr>
<tr>
<td>Inhaul</td>
<td>reverse these actions.</td>
</tr>
<tr>
<td>Hoist</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>2. Inhaul Control</td>
<td>Pull back to drop in bucket. Center (release) to control by brake 5.</td>
</tr>
<tr>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>3. Hoist Control</td>
<td>Pull back to hoist bucket. Center (release) to lower bucket by brake 6.</td>
</tr>
<tr>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>4. Boom Hoist</td>
<td>Pull back to raise boom. Push forward to lower boom. Center (released)</td>
</tr>
<tr>
<td></td>
<td>position must hold boom stationary even with boom safety pawl released.</td>
</tr>
<tr>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>5. Inhaul Brake</td>
<td>Push to hold bucket. Release to dump load.</td>
</tr>
<tr>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>6. Hoist Brake</td>
<td>Push to hold or to stop lowering bucket. Release to lower bucket.</td>
</tr>
</tbody>
</table>

#### PILE DRIVER CONTROL DIAGRAM
(Viewed from operator's seat)

<table>
<thead>
<tr>
<th>Control</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swing</td>
<td>Push forward to swing toward boom, swinging left for right side operator</td>
</tr>
<tr>
<td>Control</td>
<td>position or swinging right for left side operator position. Pull back to</td>
</tr>
<tr>
<td>Lead or</td>
<td>reverse these actions.</td>
</tr>
<tr>
<td>Pile Line</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>1. Swing Control</td>
<td>Push forward to swing toward boom, swinging left for right side operator</td>
</tr>
<tr>
<td>Control</td>
<td>position or swinging right for left side operator position. Pull back to</td>
</tr>
<tr>
<td>Lead or</td>
<td>reverse these actions.</td>
</tr>
<tr>
<td>Pile Line</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>2. Lead or Pile Line</td>
<td>Pull back to hoist piling. Center (release) to lower piling by brake 5.</td>
</tr>
<tr>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>3. Hammer Line</td>
<td>Push forward to lower piling, if provided with powered load lowering on</td>
</tr>
<tr>
<td></td>
<td>this drum.</td>
</tr>
<tr>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>4. Boom Hoist</td>
<td>Pull back to hoist hammer. Center (release) to drop hammer or to lower by</td>
</tr>
<tr>
<td>Control</td>
<td>brake 6.</td>
</tr>
<tr>
<td>5. Lead or Pile Line Brake</td>
<td>Push forward to lower hammer, if provided with powered load lowering on</td>
</tr>
<tr>
<td>Control</td>
<td>this drum.</td>
</tr>
<tr>
<td>6. Hammer Line Brake</td>
<td>Push to hold or to stop lowering load. Release to lower load.</td>
</tr>
</tbody>
</table>

#### CLAMSHELL CONTROL DIAGRAM
(Viewed from operator's seat)

<table>
<thead>
<tr>
<th>Control</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swing</td>
<td>Push forward to swing toward boom, swinging left for right side operator</td>
</tr>
<tr>
<td>Control</td>
<td>position or swinging right for left side operator position. Pull back to</td>
</tr>
<tr>
<td>Closing</td>
<td>reverse these actions.</td>
</tr>
<tr>
<td>Line</td>
<td></td>
</tr>
<tr>
<td>Holding</td>
<td></td>
</tr>
<tr>
<td>Line</td>
<td></td>
</tr>
<tr>
<td>Boom</td>
<td></td>
</tr>
<tr>
<td>Hoist</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>1. Swing Control</td>
<td>Push forward to swing toward boom, swinging left for right side operator</td>
</tr>
<tr>
<td>Control</td>
<td>position or swinging right for left side operator position. Pull back to</td>
</tr>
<tr>
<td>Closing</td>
<td>reverse these actions.</td>
</tr>
<tr>
<td>Line</td>
<td></td>
</tr>
<tr>
<td>Holding</td>
<td></td>
</tr>
<tr>
<td>Line</td>
<td></td>
</tr>
<tr>
<td>2. Closing Line</td>
<td>Pull back to close and to hoist bucket. Center (release) to hold, to open,</td>
</tr>
<tr>
<td>Control</td>
<td>or to lower bucket by brake 5.</td>
</tr>
<tr>
<td>Closing</td>
<td></td>
</tr>
<tr>
<td>Line</td>
<td></td>
</tr>
<tr>
<td>Holding</td>
<td></td>
</tr>
<tr>
<td>Line</td>
<td></td>
</tr>
<tr>
<td>3. Holding Line</td>
<td>Pull back to hoist bucket. Center (release) to hold, to open, or to lower</td>
</tr>
<tr>
<td>Control</td>
<td>bucket by brake 6.</td>
</tr>
<tr>
<td>Closing</td>
<td></td>
</tr>
<tr>
<td>Line</td>
<td></td>
</tr>
<tr>
<td>Holding</td>
<td></td>
</tr>
<tr>
<td>Line</td>
<td></td>
</tr>
<tr>
<td>4. Boom Hoist</td>
<td>Pull back to raise boom. Push forward to lower boom. Center (released)</td>
</tr>
<tr>
<td>Control</td>
<td>position must hold boom stationary even with boom safety pawl released.</td>
</tr>
<tr>
<td>Closing</td>
<td></td>
</tr>
<tr>
<td>Line</td>
<td></td>
</tr>
<tr>
<td>Holding</td>
<td></td>
</tr>
<tr>
<td>Line</td>
<td></td>
</tr>
<tr>
<td>5. Closing Line Brake</td>
<td>Push to hold or to stop lowering bucket, when control 2 is not engaged.</td>
</tr>
<tr>
<td>Control</td>
<td>Release to open or to lower bucket in conjunction with brake 6.</td>
</tr>
<tr>
<td>Closing</td>
<td></td>
</tr>
<tr>
<td>Line</td>
<td></td>
</tr>
<tr>
<td>Holding</td>
<td></td>
</tr>
<tr>
<td>Line</td>
<td></td>
</tr>
<tr>
<td>6. Holding Line Brake</td>
<td>Push to hold, to open, or to stop lowering bucket, when control 3 is not</td>
</tr>
<tr>
<td>Control</td>
<td>engaged. Release to lower bucket or when control 3 is engaged.</td>
</tr>
<tr>
<td>Closing</td>
<td></td>
</tr>
<tr>
<td>Line</td>
<td></td>
</tr>
<tr>
<td>Holding</td>
<td></td>
</tr>
<tr>
<td>Line</td>
<td></td>
</tr>
</tbody>
</table>

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LIFTING CRANE SHEAVE AND DRUM SIZES—SAE J881

Scope—This SAE Standard covers minimum dimensional relations for sheaves, drums and wire rope for mobile, construction type lift cranes.

FIG. 1—SHEAVE AND DRUM

PD = Pitch diameter of sheave or drum, measured to center-line of rope.
TD = Tread diameter of sheave or drum, measured to bottom of groove (TD + RD = PD)
RD = Nominal rope diameter

TABLE 1

<table>
<thead>
<tr>
<th>Use</th>
<th>Minimum Ratio PD/RD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load hoisting sheaves, on boom</td>
<td>18.0 to 1</td>
</tr>
<tr>
<td>Load hoisting sheaves, in traveling blocks</td>
<td>16.0 to 1</td>
</tr>
<tr>
<td>Load hoisting drum</td>
<td>18.0 to 1</td>
</tr>
<tr>
<td>Boom hoisting sheaves</td>
<td>15.0 to 1</td>
</tr>
<tr>
<td>Boom hoisting drum</td>
<td>15.0 to 1</td>
</tr>
</tbody>
</table>

APPENDIX F

CRANE LOAD STABILITY TEST CODE—SAE J765

SAE Recommended Practice

1. Purpose—The purpose of this test is to determine the maximum capacity of a crane to counterbalance loads applied on its hook block. The capacity of the crane is reported in terms of the load in pounds and its corresponding radius in feet for a specified position of the superstructure with respect to the mounting.

2. Scope—This test may be used for all revolving cranes wherein the capacity of the crane to support loads is based on its resistance to overturning. It is not applicable to cranes wherein the capacity of the crane is based on structural strength or available hoisting power.

3. Definitions

3.1 Balance Point—The condition of crane loading wherein the load moment acting to overturn the crane is equal to the maximum moment.

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of the crane available to resist overturning. On wheel mounted cranes where balance loads are supported over an end of the mounting equipped with free-oscillating dual axes, the balance point, without outriggers set, is determined with the oscillating center of the axes or “bogie axle” functioning as the fulcrum.

3.2 Axis of Rotation—A vertical line thru the axis around which the structure rotates, before load is applied to the crane hook.

3.3 Load—The force acting to unbalance a crane; it results from (1) the gravitation force created by hook block and all items suspended from the hook block; (2) force exerted by hoisting on a fixed anchor; or (3) a combination of the above forces.

3.4 Radius of Load—The horizontal distance from a projection of the axis of rotation to the supporting surface, before loading, to the center of vertical hoist line or tackle with load applied.

3.5 Specified—The term specified, where used herein, is construed to mean the recommendation of the manufacturer, the user, the testing agency or any agreement between these parties.

4. Limitations—It is critically important that the manufacturer's maximum permissible load and radius limitations are not exceeded since these limitations are frequently based on structural strength rather than resistance to overturning. In no case should users of this code perform balance capacity lifts with the load supported on one outrigger or support point because of the structural limitations and safety hazards involved.

5. Methods—Two methods for conducting these tests are covered.

In the first, the load is applied by suspending a weight of predetermined magnitude and adjusting its position horizontally to the balance point. In the second, the load is applied by hoisting on a fixed anchor and adjusting the hoisting force and boom so that the hoist line is vertical while the force necessary to bring the crane to the balance point is applied to the hoist line.


6.1 Facilities common to both suspended-load and anchor-load methods:

6.1.1 A concrete or other firm supporting surface, level within ± 1% of grade.

6.1.2 Steel tape.

6.1.3 Tire pressure gage; accuracy ± 3% of measured pressure.

6.1.4 Means for projecting the crane axis of rotation to the test course surface.

6.1.5 Means for measuring the horizontal distance from the axis of rotation to the center of gravity of the load.

6.1.6 Means for determining the weight of test weights, hook block, slings and other auxiliary equipment; accuracy ± 1 1/4% of measured load.

6.2 Facilities necessary for the suspended-load method only:

6.2.1 Test weights, as required to make-up specified loads, and to provide additional load in ten pound increments.

6.3.1 Means for determining the weight of specified load within ± 1/4%. Record this value.

6.3.2 With the crane superstructure in the specified position, hoist the load free of the test course at a radius where the crane is stable; then, boom the load out to a radius near the balance point.

NOTE: The load should be kept near the test course surface in order to avoid excessive tipping of the crane. Also, the crane should be safeguarded—by blocking or other means—from overturning backward should the load line or other tackle fail while under load.

7. Procedure

7.1 Common to both suspended-load and anchor-load methods:

7.1.1 Service and adjust the crane as applicable to assure specified conditions of:

(a) Lubrication
(b) Fuel supply
(c) Tire inflation
(d) Coolant supply
(e) Track tension
(f) Bolts, pins, cable fittings, and other load bearing components
(g) Clutches, brakes, and other power transmission components
(h) Boom length and rigging

7.1.2 Operate the crane under partial load sufficiently long to assure operator proficiency and proper machine function. In the absence of specific recommendations, a new machine should be operated for at least four hours. Service and adjust the machine to specified tolerances at conclusion of the “Limbering-Up” operation.

7.1.3 Locate the crane on the test course in position for loading and lock the travel brakes.

7.1.4 Set outriggers, if used, and jack the crane to a position where the tires or tracks within the boundary of the outriggers are unloaded.

7.1.5 Vertically project the superstructure axis-of-rotation to the surface of the test course and mark its location.

7.2 Procedure for suspended loads:

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### FIG. 1—PAGE 1 OF TEST SUMMARY

<table>
<thead>
<tr>
<th>Position of Superstructure</th>
<th>Without Outriggers</th>
<th>With Outriggers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Load (lb)</td>
<td>Radius (ft)</td>
</tr>
<tr>
<td></td>
<td>Load (lb)</td>
<td>Radius (ft)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Remarks</th>
</tr>
</thead>
</table>

Test Engineer: __________________ Date of Test: ________

7.2.1 Prepare test load including test weights, hook block, slings, and other auxiliary equipment, such as load basket, that make up the specified load weight within ± 1%. Record this value.

7.2.2 With the crane superstructure in the specified position, hoist the load free of the test course at a radius where the crane is stable; then, boom the load out to a radius near the balance point.

NOTE: The load should be kept near the test course surface in order to avoid excessive tipping of the crane. Also, the crane should be safeguarded—by blocking or other means—from overturning backward should the load line or other tackle fail while under load.

7.2.3 Alternately measure the radius of load and add a ten pound increment to the load until the load overcomes the stability of the crane. The radius of load and load weight last obtained, before the load overcame the stability of the crane, shall be recorded as the balance point condition.

7.3 Procedure for anchor-load method:

7.3.1 Determine the weight of the hook block and any part of the force measuring means that will be suspended by the hook block. Record these values.

7.3.2 Install the force measuring means between the hook and anchor. With the crane in the specified position for lift and with the load line kept vertical while under load:

(a) Apply hoisting force to the anchor until the indicated magnitude of force tends to diminish with continued hoisting.

(b) Record the observed hoisting force and the radius of load. The peak hoisting force in pounds plus the weight of the hook block and other equipment suspended between the hook block and anchor constitutes the load for record.

8. Computation and Records

8.1 Capacity Curve—Where it is desired to determine the balance point capacity of a crane throughout a range of loads or radii, follow...
procedures as outlined for individual determinations, making sure that load and radius are determined for each extreme of the range and at a sufficient number of intermediate points to permit plotting a curve. Plot a curve showing the maximum capacity of the crane with the load in pounds as ordinate and radii in feet as abscissa.

8.2 Test Records—Record a description of the crane, positions for test, load data and radius of load data on the Physical Dimensions Test Summary sheets.

FIG. 2—PAGE 2 OF TEST SUMMARY.

FIG. 3—PAGE 3 OF TEST SUMMARY.
1. Purpose—The purpose of this SAE Standard is to set forth wire-rope strength factors that have been proved by design and operating practice to be consistent with safety, economy, space, weight and other requirements peculiar to mobile, construction-type, lifting cranes.

2. Scope—This standard applies to all mobile, construction-type, lifting cranes as equipped for operation with hook, clamshell, magnet and grapple attachments. It is not applicable to excavating and demolition attachments such as shovels, hoes, draglines and wrecking balls.

3. Basis for Determinations—

3.1 Strength Factors—Strength factors shall be based on the numerical values obtained by dividing the nominal breaking strength of the rope in a load supporting system by the total force applied to the system.

3.2 Wire-Rope Strength Factors—Wire-rope strength factors shall be not less than those specified in paragraph 4 of this standard with the combination of listed boom length, recommended wire rope, listed operating radius, and rated load or other recommended operating condition that produces the maximum force in the particular rope system under consideration.

3.3 Forces—All forces shall be considered static as produced by the boom and suspended load with the effects of motion from lifting, lowering, swinging, or traveling.

3.4 Total Force—Total force in the rope system under consideration shall be the force resulting from the effects of the suspended load and structures.

4. Wire-Rope Strength Factors—

4.1 For Supporting Rated Loads (Including Boom Suspensions)—

(a) The strength factor for live or running ropes that wind on drums or pass over sheaves shall be not less than 3.5.

(b) The strength factor for standing or guy ropes shall be not less than 3.0.

4.2 For Supporting the Boom and the Working Attachments at Recommended Travel Positions and Boom Lengths—

(a) The strength factor for live or running ropes shall be not less than 3.5.

(b) The strength factor for standing or guy ropes shall be not less than 3.0.

4.3 For Supporting the Boom under Recommended Erection Conditions—

(a) The strength factor for live or running ropes shall be not less than 3.0.

(b) The strength factor for standing or guy ropes shall be not less than 2.5.

5. Wire-Rope Inspection—Assurance of safety and economy in use of construction-type cranes dictates the requirement for a program of periodic inspections of the condition of all load supporting wire rope. Environmental and use factors such as abrasion, wear, fatigue, corrosion, improper reeving and kinking, are often of greater significance in determining the safely usable life of wire-rope than are conservative strength factors based on new-rope conditions. Appendices A and B of this standard set forth recommended considerations for inspection of wire-rope and a suggested format for recording pertinent observations. The crane operator should inspect wire-rope daily when the crane is in service and prior to operation after a period of standby. Critical inspection of all ropes should be made by a competent rope inspector and pertinent observations recorded not less than weekly when the crane is in continuous service and prior to operation when the crane is removed from storage.

APPENDIX A—WIRE-ROPE INSPECTION

1. Evidence of rope deterioration from corrosion should be cause for replacement.

2. More than one broken wire in any one strand should be cause for caution. Breaks that occur on the worn crowns of the outside wires indicate normal deterioration. Breaks that occur in the valleys between strands indicate some abnormal condition, possibly fatigue and breakage of other wires not readily visible. One or more valley breaks should be cause for replacement.

3. Wire breaks generally occur in those portions of a wire rope which pass over sheaves, wind onto drums, or receive mechanical abuse. Breaks that occur near attached fittings are apt to result from fatiguing stresses concentrated in these localized sections. Breaks of the latter type should be cause for replacement of the rope or renewal of the attachment to eliminate the locally fatigued area.

4. Heavy wear or broken wires may occur in sections under equalizer sheaves or other sheaves where rope travel is limited, or in contact with saddles. Particular care should be taken to inspect ropes at these points.

5. Rope stretch is generally greatest during initial stages of operation when the strands are becoming adjusted and seated. This is accompanied by some reduction in rope diameter, but not to the extent that the condition of the rope can be judged on this basis.

6. Time for rope replacement is indicated by the extent of abrasion, scrubbing and peening on the outside wires, broken wires, evidence of pitting or severe corrosion, kink damage, or other mechanical abuse resulting in distortion of the rope structure.

7. Sheaves, guides, guides, drums, flanges and other surfaces contacted by wire rope during operation should be examined at the time of inspections. Any condition harmful to the rope in use at the time should be corrected. The same equipment, and particularly sheave and drum grooves, should be inspected and placed in proper condition before a new rope is installed.

8. Any of the following listed conditions should be cause for rope replacement:

(a) In running ropes, six randomly distributed broken wires in one rope lay, or three broken wires in one strand in one rope lay. (A rope lay is the length along the rope in which one strand makes a complete revolution around the rope. See Fig. 1.)

(b) In pendants or standing ropes, evidence of more than one broken wire in one rope lay.

(c) Abrasion, scrubbing or peening causing loss of more than 1/8 the original diameter of the outside wires.

(d) Evidence of rope deterioration from corrosion.

(e) Severe kinking, severe crushing, or other damage resulting in distortion of the rope structure.

(f) Evidence of any heat damage resulting from a torch or arc caused by contact with electrical wires.

(g) Reduction from nominal diameter of more than 1/4 in., for diameters up to and including 3/4 in.; 3/4 in. for diameters 7/4 in. to 1 1/2 in.; 3/8 in. for diameters 1 1/2 in. to 1 1/2 in. Marked reduction in diameter indicates deterioration of the core resulting in lack of proper support for the load carrying strands. Excessive rope stretch or elongation may also be an indication of internal deterioration.

(h) Evidence of “bird-caging” or other distortion resulting in some members of the rope structure carrying more load than others. See Fig. 2.

(i) Noticeable rusting or development of broken wires in the vicinity of attachments.

NOTE: If this condition is localized in an operating rope and the section in question can be eliminated by making a new attachment, this can be done rather than replacing the entire rope.

APPENDIX B—WIRE-ROPE INSPECTION LOG

See Fig. 3.
FIG. 1—TYPICAL ROPE CONSTRUCTION

FIG. 2—BIRD CAGING

FIG. 3—WIRE ROPE INSPECTION LOG
APPENDIX H
HAND SIGNALS

(Recommended by ANSI Standards Committee B30, Safety Code for Cranes, Derricka, Hoists, Jacks and Slings, and reproduced from the Proposed ANSI Standard Safety Code for Crawlers, Locomotive and Truck Cranes, ANSI B30.5 with the permission of the Publisher, The American Society of Mechanical Engineers.)

HOIST. With forearm vertical, forefinger pointing up, move hand in small horizontal circle.

LOWER. With arm extended downward, forefinger pointing down, move hand in small horizontal circles.

USE MAIN HOIST. Tap fist on head; then use regular signals.

USE WHIP LINE. (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 giving the motion signal. (Hoist Slowly shown as example)

RAISE THE BOOM AND LOWER THE LOAD. With arm extended, thumb pointing up, flex fingers in and out as long as load movement is desired.

LOWER THE BOOM AND RAISE THE LOAD. With arm extended, thumb pointing down, 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, hold position rigidly.

EMERGENCY STOP. Arm extended, palm down, move hand rapidly right and left.

TRAVEL. Arm extended forward, hand open and slightly raised, make pushing 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 crawler cranes only)

TRAVEL. (One Track) Lock the track on side indicated by raised fist. Travel opposite track in direction indicated by circular motion of other fist, rotated vertically in front of body. (For crawler 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.
BANTAM DIVISION
Koehring Company
Waverly, Iowa

BUCYRUS-ERIE CO.
South Milwaukee, Wisconsin

CLARK EQUIPMENT CO.
Aurora, Illinois
Austin-Western Division
Lima, Ohio

CRANE AND EXCAVATOR DIVISION
FMC Corp.
Cedar Rapids, Iowa

DEERE & COMPANY
Moline, Illinois

DROTT MFG. DIVISION
J I Case Co.
Wausau, Wisconsin

FORD MOTOR CO.
Troy, Michigan
Ford Tractor Operations

GALION MFG. DIVISION
Dresser Industries, Inc.
Galion, Ohio

GROVE MFG. CO.
Shady Grove, Pennsylvania

HARNSCHFEGER CORPORATION
Milwaukee, Wisconsin

HEIN-WERNER CORPORATION
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