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NATIONAL IRANIAN OIL REFINING & DISTRIBUTION COMPANY
NATIONAL IRANIAN OIL ENGINEERING
& CONSTRUCTION COMPANY

NIOEC SP

NIOEC SPECIFICATION FOR MOBILE CRANES-POWER DRIVEN

FIRST EDITION

JULY, 2005

THIS SPECIFICATION IS THE PROPERTY OF NATIONAL IRANIAN OIL ENGINEERING & CONSTRUCTION COMPANY. IT IS CONFIDENTIAL AND ALL RIGHTS RESERVED TO THE OWNER. NEITHER WHOLE NOR ANY PART OF THIS DOCUMENT MAY BE DISCLOSED TO ANY THIRD PARTY, REPRODUCED, STORED IN ANY RETRIEVAL SYSTEM OR TRANSMITTED IN ANY FORM OR BY ANY MEANS WITHOUT THE PRIOR WRITTEN CONSENT OF THE NATIONAL IRANIAN OIL ENGINEERING & CONSTRUCTION COMPANY.

IN THE NAME OF GOD**FOREWORD**

By their very nature, technical Specifications are continuously subject to modifications and revisions. To strengthen their merit and usefulness, continuous improvements, addendum, deletion of disparate information and consequently provision of updated revisions are to be made in order to ascertain that such Specifications meet the current requirements, inclusive of Iranian Petroleum Standards (IPS) and the recognized and acceptable national and international Standards, as well as the optimal codes and practices based on the accumulated in-house know-how and plant knowledge and experiences.

However, in reality, due to several reasons, not to mention the complexity of the matter, the ultimate goal of continuous direct embedment of the required changes on the relevant Specifications may be far reaching. Therefore, in the interim periods between the officially issued revisions, the required changes will appear in other documents related to the engineering and design work of the ongoing projects.

In response to the initiative of the Design and Engineering Directorate, and considering that the task of the execution of several important and mega projects for the realization of the new oil refineries, pipelines and oil terminals as well as improvements of the existing facilities, has been assigned to NIOEC, it was decided to update the NIOEC Specifications and to issue new official revisions.

The Design and Engineering Directorate was itself entrusted to carry out this important task, and as such by forming several special technical committees, working in close co-operation and cohesion and sharing their expertise and knowledge, the updated and revised NIOEC Specifications were successfully prepared and complied.

These Specifications are intended to be used for Oil Refineries, Distribution Depots, Oil Terminals, Pipelines and Pump Stations within NIOEC's projects, and have been proven to be of high value for such purposes. It must however be appreciated that these Specifications represent the minimum requirements and should in no way be interpreted as a restriction on the use of better procedures, engineering and design practices or materials.

We encourage and highly appreciate the users and other clear sighted and experts to send their comments on the Specifications to the Design and Engineering Director of NIOEC for evaluation and approval.

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NOTES:

- 1) THIS SHEET IS A RECORD OF ALL REVISIONS TO THIS SPECIFICATION.
- 2) WHEN APPROVED EACH REVISION SHALL BE CONSIDERED AS A PART OF THE ORIGINAL DOCUMENT.
- 3) NUMBER OF PAGES EXCLUDES THIS SHEET AND THE COVER SHEET.

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INTRODUCTION

To satisfy the requirements of this NIOEC Specification, Iranian Petroleum Standard IPS-M-GN-340(1) (Revised October 2013) with the modifications as specified herein after shall be strictly followed.

Articles 1 through 3 of this document replace entirely 1 through 4 articles in the referenced IPS Standard.

1. SCOPE

This Specification defines NIOEC minimum requirements for the design, construction and testing of power-driven mobile and semi-mobile cranes either road wheel mounted, crawled mounted, or truck mounted, including any combination of the following characteristics, for use in refinery/ oil plant, distribution depots, pump stations and pipelines.

- a) Fully mobile.
- b) Semi-mobile.
- c) Fully slewing.
- d) Part-slewing.
- e) Non-slewing.

The Specification covers articulated jib cranes mounted on load carrying vehicles and generally referred to as lorry loaders.

Compliance by the crane Manufacturer with the provisions of this Specification does not relieve him of the responsibility of furnishing the cranes and accessories of proper design, to meet all requirements at specified service conditions.

Deviations from this specification will only be permitted on obtaining written approval from NIOEC.

Resolution on cases not explicitly stipulated in this Specification, or on cases where conflicts may arise among the requirements of the international standards, shall be made through written consent and approval of NIOEC.

The Manufacturer shall supply with the tender the appropriate information indicated in Appendix B regarding the construction of the crane.

2. REFERENCES

The following standards, codes, and specifications, to the extent specified hereinafter, shall constitute a part of this NIOEC Specification. Latest edition of the undated referenced documents and the cited edition of the dated references shall apply. The applicability of changes made to the dated references, after the cited date shall be mutually agreed upon between NIOEC and the Vendor /Contractor.

AGMA (AMERICAN GEAR MANUFACTURERS ASSOCIATION)

210.02	"Surface Durability of Spur Gear Teeth"
211.02	"Surface Durability of Helical and Herring Bone Gear"
220.02	"Rating the Strength of Spur Gear Teeth"

AISC (AMERICAN INSTITUTE FOR STEEL CONSTRUCTION)

"Specification for the Design Fabrication and Erection of Structural Steel for Buildings"

AISI (AMERICAN IRON AND STEEL INSTITUTE)**API (AMERICAN PETROLEUM INSTITUTE)**

SPEC 9A "Specification for Wire Ropes"

ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

Boiler and Pressure Vessel Code, Sec. IX "Welding and Brazing Qualification"

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

A 320 "Specification for Alloys-Steel Bolting Materials for Low Temperature Service"

A 578 "Specification for Straight-Beam Ultrasonic Examination of Plain and Clad Steel Plates for Special Applications"

A 770 "Specification for Through-Thickness Tension Testing Steel Plates for Special Applications"

E 186 "Referenced Radiographs for Heavy-Walled (51 to 114 mm) Steel Casting"

E 280 "Referenced Radiographs for Heavy-Walled (114 to 305 mm) Steel Castings"

E 446 "Referenced Radiographs for Steel Castings up to 51 mm in Thickness"

AWS (AMERICAN WELDING SOCIETY)

D 1.1 "Structural Welding Code"

D 14.3 "Specification for Welding Earthmoving and Construction Equipment"

BSI (BRITISH STANDARDS INSTITUTE)

2573: Part 1 "Specification for Classification, Stress Calculations and Design Criteria for Structures"

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-M-GN-340(1) "Material Standard for Mobile Cranes-Power Driven"

IPS-M-GN-160 "Hooks, Shackles, Eye Bolts and chains"

IPS-M-PM-290 "Reciprocating Internal Combustion Engines"

NIOEC-SP (NIOEC SPECIFICATIONS)

NIOEC-SP-00-10 "NIOEC Specification for Units"

NIOEC-SP-60-00 "NIOEC Specification for General Design Philosophy for Electrical System"



NIOEC-SP-60-02	"NIOEC Specification for Low Voltage Induction Motors"
NIOEC-SP-60-05	"NIOEC Specification for Medium & high Voltage power Cables"
NIOEC-SP-60-16	"NIOEC Specification for Low Voltage Cable and Wires"
NIOEC-SP-60-23	"NIOEC Specification for Turbine Driven Synchronous Generators"
NIOEC-SP-60-31	"NIOEC Specification for Electrical Bulk Material"

SAE (SOCIETY OF AUTOMOTIVE ENGINEERS)

J 429	"Mechanical and Material Requirements for Externally Threaded Fasteners"
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2.1. Equivalent to IPS Standard

Substitute the following IPS Standards as referred to throughout IPS-M-GN-340 to relevant NIOEC's Specifications as follows:

<u>IPS Standard</u>	<u>Relevant NIOEC Specification</u>
IPS-M-EL-161	NIOEC-SP-60-00
IPS-M-EL-271	NIOEC-SP-60-16
IPS-M-EL-272	NIOEC-SP-60-05
IPS-M-EL-132	NIOEC-SP-60-02
IPS-M-EL-138	NIOEC-SP-60-23

3. UNITS

International system of units (SI) shall be used in accordance with NIOEC-SP-00-10, unless otherwise specified.

MATERIAL STANDARD

FOR

MOBILE CRANES-POWER DRIVEN

ORIGINAL EDITION

JULY 1997

This standard specification is reviewed and updated by the relevant technical committee on Oct. 2013. The approved modifications are included in the present issue of IPS.

FOREWORD

The Iranian Petroleum Standards (IPS) reflect the views of the Iranian Ministry of Petroleum and are intended for use in the oil and gas production facilities, oil refineries, chemical and petrochemical plants, gas handling and processing installations and other such facilities.

IPS is based on internationally acceptable standards and includes selections from the items stipulated in the referenced standards. They are also supplemented by additional requirements and/or modifications based on the experience acquired by the Iranian Petroleum Industry and the local market availability. The options which are not specified in the text of the standards are itemized in data sheet/s, so that, the user can select his appropriate preferences therein

The IPS standards are therefore expected to be sufficiently flexible so that the users can adapt these standards to their requirements. However, they may not cover every requirement of each project. For such cases, an addendum to IPS Standard shall be prepared by the user which elaborates the particular requirements of the user. This addendum together with the relevant IPS shall form the job specification for the specific project or work.

The IPS is reviewed and up-dated approximately every five years. Each standards are subject to amendment or withdrawal, if required, thus the latest edition of IPS shall be applicable

The users of IPS are therefore requested to send their views and comments, including any addendum prepared for particular cases to the following address. These comments and recommendations will be reviewed by the relevant technical committee and in case of approval will be incorporated in the next revision of the standard.

Standards and Research department

No.17, Street14, North kheradmand

Karimkhan Avenue, Tehran, Iran.

Postal Code- 1585886851

Tel: 021-88810459-60 & 021-66153055

Fax: 021-88810462

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GENERAL DEFINITIONS:

Throughout this Standard the following definitions shall apply.

COMPANY:

Refers to one of the related and/or affiliated companies of the Iranian Ministry of Petroleum such as National Iranian Oil Company, National Iranian Gas Company, National Petrochemical Company and National Iranian Oil Refinery And Distribution Company.

PURCHASER:

Means the "Company" where this standard is a part of direct purchaser order by the "Company", and the "Contractor" where this Standard is a part of contract documents.

VENDOR AND SUPPLIER:

Refers to firm or person who will supply and/or fabricate the equipment or material.

CONTRACTOR:

Refers to the persons, firm or company whose tender has been accepted by the company.

EXECUTOR:

Executor is the party which carries out all or part of construction and/or commissioning for the project.

INSPECTOR:

The Inspector referred to in this Standard is a person/persons or a body appointed in writing by the company for the inspection of fabrication and installation work.

SHALL:

Is used where a provision is mandatory.

SHOULD:

Is used where a provision is advisory only.

WILL:

Is normally used in connection with the action by the "Company" rather than by a contractor, supplier or vendor.

MAY:

Is used where a provision is completely discretionary.

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1. SCOPE

1.1 This IPS Standard specifies the requirements for the design, construction and testing of power-driven mobile and semi-mobile cranes either road wheel mounted, crawler mounted, or truck mounted, including any combination of the following characteristics, for use in Iranian Petroleum Industries.

- a) Fully mobile.
- b) Semi-mobile.
- c) Fully slewing.
- d) Part-slewing.
- e) Non-slewing.

The standard covers articulated jib cranes mounted on load carrying vehicles and generally referred to as truck cranes.

Typical mobile crane types and jib configuration including typical crane features are shown in Figs. 2 to 6.

1.2 No deviations or exceptions from this Standard shall be permitted without the written approval of the Company.

The intended deviations shall be listed separately by the Vendor and supported by reasons thereof for purchaser's consideration.

1.3 Compliance by the crane Manufacturer with the provisions of this Standard does not relieve him of the responsibility of furnishing the cranes and accessories of proper design, to meet all requirements at specified service conditions.

1.4 All the necessary information regarding the conditions under which the crane is to be used, together with the information indicated in Appendix A, shall be supplied by the Purchaser with enquiry or order.

1.5 The Manufacturer shall supply with the tender the appropriate information indicated in Appendix B regarding the construction of the crane.

Note:

This standard specification is reviewed and updated by the relevant technical committee on Oct. 2013. The approved modifications by T.C. were sent to IPS users as amendment No. 1 by circular No. 399 on Oct. 2013. These modifications are included in the present issue of IPS.

2. REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the company and the vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

AGMA (AMERICAN GEAR MANUFACTURERS ASSOCIATION)

ANSI/AGMA: 2001-D04 "Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth"

ANSI/AGMA: 6013-A06 "Standard for Industrial Enclosed Gear Drives"

AISC (AMERICAN INSTITUTE FOR STEEL CONSTRUCTION)

ANSI/AISC 360 "Specification for Structural Steel Buildings"

AISI (AMERICAN IRON AND STEEL INSTITUTE)**API (AMERICAN PETROLEUM INSTITUTE)**

SPEC 9A "Specification for Wire Ropes"

ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

Sec. IX "Welding and Brazing Qualification"

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

A320/A320 M "Standard Specification for Alloys-Steel Bolting Materials for Low Temperature Service"

A578/A578 M "Standard Specification for Straight-Beam Ultrasonic Examination of Plain and Clad Steel Plates for Special Applications"

A770/A770 M "Standard Specification for Through-Thickness Tension Testing Steel Plates for Special Applications"

E186 "Standard Referenced Radiographs for Heavy-Walled (51 to 114 mm) Steel Casting"

E280 "Standard Referenced Radiographs for Heavy-Walled (114 to 305 mm) Steel Castings"

E446 "Standard Referenced Radiographs for Steel Castings up to 51 mm in Thickness"

AWS (AMERICAN WELDING SOCIETY)

D1.1/D1.1M "Structural Welding Code"

D14.3/D14.3M "Specification for Welding Earthmoving and Construction and Agricultural Equipment"

BSI (BRITISH STANDARDS INSTITUTE)

2573: Part 1: 1999 "Specification for Classification, Stress Calculations and Design Criteria for Structures"

IPS (IRANIAN PETROLEUM STANDARDS)

[IPS-M-EL-271](#) "Low Voltage Cables and Wires"

[IPS-M-EL-272](#) "Medium and High Voltage Power Cables"

[IPS-M-EL-161](#) "General Electric Items"

[IPS-M-EL-132](#) "Induction Motors"

[IPS-M-EL-138](#) "Generators"

[IPS-M-EL-271](#) "Low Voltage Cables and Wires"

[IPS-M-EL-272](#) "Medium and High Voltage Power Cables"

[IPS-M-GN-160](#)

“Lifting Hooks, Shackles and Eye Bolts”

[IPS-M-PM-290](#)

“Internal Combustion Reciprocating Engines”

SAE (SOCIETY OF AUTOMOTIVE ENGINEERS)

J 429

“Mechanical and Material Requirements for Externally Threaded Fasteners”

3. CONFLICTING REQUIREMENTS

In case of conflict between documents relating to the inquiry or order the following priority of documents shall apply:

First priority : Purchase order and variations there to

Second priority : Data sheets

Third priority : This Standard specification

All conflicting requirements shall be referred to purchaser in writing. The Purchaser will issue confirmation document if needed for clarification.

4. UNITS

This Standard is based on International System of Units (SI), as per [IPS-E-GN-100](#) except where otherwise specified.

5. DEFINITION OF TERMS

For the purposes of this IPS Standard, the following definitions apply.

5.1 Anchorage

Means of securing the base of an articulated jib crane to a vehicle chassis, or a steel wire rope to a drum or to the crane structure.

5.2 Articulation

The ability to pivot about a pin joint.

5.3 Articulated Jib

A jib having two or more members capable of articulation.

5.4 Blocking-Up Base (Blocked Condition)

The effective dimensions of the supporting base when outriggers or other supporting means are used.

5.5 Coefficient of Utilization

The ratio of the minimum breaking load of the rope to its working load limit.

5.6 Derricking or Luffing

Angular movement of the crane jib in a vertical plane.

Note:

Cranes which lift their loads by derricking the jib while the load is suspended from a fixed

hook on the jib should be described as lifting their loads by derricking only.

5.7 High of Lift

The vertical distance between the floor level or datum level, and the lowest point of the throat of the hook when the hook is in the highest working position.

5.8 Hoisting

The motion of lifting or lowering of the load in a vertical direction.

5.9 Jib Angle

Jib angle is the angle subtended between the horizontal plan and a jib axis as defined by the Manufacturer.

5.10 Jib Length

The shortest distance between the centers of the fulcrum of the jib and jib head pulley pin.

5.11 Minimum Breaking Load

The minimum breaking load value given in the appropriate standard or specification below which a sample of the rope will not fail when tested in the prescribed manner.

5.12 Fully Mobile

Cranes capable of traveling under their own power with loads up to the maximum for which they are designed, suspended at any point within the working range.

5.13 Semi-Mobile

Cranes which are not designed to travel with loads suspended.

5.14 Mobile crane

A combination of a load carrying vehicle and an articulated jib crane that is used for the handling of goods on or off the vehicle.

5.15 Outreach

The horizontal distance from the centreline of the lifting hook to the nearest point of the machine other than the jib. (This dimension varies in accordance with the operating conditions of the machine.)

5.16 Outrigger Beam

A supporting device that can be extended at the side of a mobile crane and is normally capable of being used to jack the crane into a level attitude.

5.17 Overload Prevention Device

A device that prevents the operator moving load into an overload condition.

5.18 Radius

The horizontal distance measured at ground level between the centreline of the hook and perpendicular projected through the center of rotation.

Note:

In the case of a non-slewing crane, the horizontal distance from the centreline of a lifting hook to the centreline of the nearest axle, bogie or track, measured at ground level, can be

assumed to be the radius for the purpose of this definition.

5.19 Safe Working Load (SWL)

The maximum load which can be safely handled by a crane at a specified position and under specified conditions. The safe working load includes the weight of the hook or load handling device unless otherwise specified.

5.20 Slewing

Rotary motion of a crane jib and superstructure about a vertical axis.

5.21 Fully-Slewing

The ability to slew continuously in either direction with a load, up to the maximum for which the crane is designed, suspended.

5.22 Part-Slewing

The ability to slew but unable to comply with the definition of 5.21.

5.23 Stabilizer

A load supporting leg usually extended outwards from the side of a crane or mobile crane to provide more stable base. The leg can be extended to reach the ground either manually or hydraulically. It requires to be retracted, stowed and secured for transit.

5.24 Tail Radius

The maximum distance between the center of rotation and any part of the revolving superstructure other than the jib.

5.25 Telescoping

The extension or retraction of the jib along its longitudinal axis by movement of the sections contained within the jib.

5.26 Tipping

A crane is deemed to be in a condition of tipping when it is subjected to an overturning moment which cannot be increased, even by a small amount, without causing the crane to overturn.

5.27 Stable

A crane is said to be stable when the sum of the stabilizing moments is greater than the sum of the overturning moments.

5.28 Working Load Limit

The maximum load which an item of equipment is designed to raise, lower or suspend.

5.29 Dead Loads

All the loads of constant magnitude and position that act permanently on the structure or member.

5.30 Live Loads

Any load except wind load that gives rise to variation of stress in a member. Such variation may be due to any change of position or magnitude of an externally applied load or to the movement of the crane structure itself.

5.31 Inertia Forces

The forces produced by change of velocity.

5.32 Wind Load

The forces produced by the velocity of the wind, which is assumed to act horizontally.

5.33 Permissible Working Stress

The stress numerically equal to the basic stress multiplied by the relevant duty factor and the factor corresponding to the load combination.

5.34 Permissible Fatigue Stresses

Stresses as set out in Section 8 of BS 2573 part 1.

5.35 Service Conditions

The crane is deemed to be under service conditions when it is operating without load or with a load up to the maximum safe working load.

5.36 Critical Component

Any component of the crane assembly devoid of redundancy and/or auxiliary restraining devices whose failure would result in an uncontrolled descent of the load or uncontrolled rotation of the upper structure.

6. STRUCTURAL DESIGN**6.1 Analysis**

All critical structural components shall be designed to conform with the allowable unit stresses specified in the latest edition of the AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings, when subjected to dead load, plus the design and horizontal loads defined in Paragraphs 6.2. For structural steels other than those listed in the AISC specification, Compatibility with the AISC allowable unit stresses should be established and documented through discussions with the AISC technical staff.

Connecting joints (welded, pinned or bolted) shall develop either the load carried by the connected members or the strength of the connected members based on AISC allowables, but in no case less than 50% of the tensile strength of the controlling member. Allowable shear stresses and width-to-thickness ratios shall be in accordance with the applicable provisions of AISC.

6.2 Application of Loads

The structure as a whole and each part of it shall be designed to withstand the load combinations given in latest edition of BSI Standard 2573: Part 1, Section 3, including all aspects such as horizontal loads, loads due to climatic conditions and natural phenomena, impact factor, and etc.

6.3 Material Requirements**6.3.1 Materials**

Materials to be employed in the Manufacture and fabrication of critical components of the crane shall comply with the Manufacturer's design requirement for strength and fracture toughness:

1) Metals

The design requirement shall define the following properties of metallic materials:

Chemical Composition Limits Heat Treatment Condition Mechanical property Limits

a) Yield Strength

- b) Tensile Strength
- c) Elongation
- d) Fracture Toughness

2) Testing

The design requirement specification shall detail the methods of testing to verify the specified properties are present in the component in the as manufactured or as fabricated condition. To the maximum extent possible, all materials shall be purchased to specifications of recognized Standardization Organization.

3) Wire Rope

Rope shall be of construction specified by the crane manufacturer for that service. The requirements of the latest edition of API spec. 9A, "API Specification for Wire Rope" shall be the minimum specification for wire ropes to be employed. Rotation resistant ropes and fiber core ropes shall not be used for boom hoist reeving.

The design factor for wire rope shall be the total nominal strength of all parts of wire rope in the system divided by the load imposed while supporting the following loads:

- a) For load hoist ropes, the load to be lifted.
- b) For other ropes, the dead load plus the load to be lifted.

6.3.2 Traceability

Traceability of materials for critical components and parts shall be achieved through a systematic program of serialization and identification indexed to process, inspection, and test records of controlled manufacturing procedures. The Manufacturing procedures shall be in sufficient written detail to permit duplication of the original processing at any time specified. Documentation of material origins shall be that of the basic producer in lieu of certifications prepared by third party material suppliers. In the absence of supporting documentation, materials shall not be employed in fabrication until the Manufacturer conducts or has conducted tests and examinations to verify compliance with design requirements. Critical structural components shall not be produced from materials which lack supporting documentation to verify the properties are as specified in the design and manufacturing specifications.

6.3.3 Fracture toughness

All critical components of the crane shall exhibit Charpy impact energy values assuring the transition from brittle to ductile fractures at least indexed at the lowest anticipated service temperature. Other appropriate fracture control plans considering toughness, allowable flaw size, and inspection requirements may be employed if desired. If a fitness for purpose criteria is employed, that details of the analysis shall be documented for examination, upon request, by the Purchaser.

The design service temperature shall be indicated on the nameplate.

6.3.4 Castings

1) Prototype Castings

The validity of the casting procedure for all critical component castings shall be verified by conducting examinations and tests on the first lot cast and/or each change in pattern design or pouring practice. Destructive testing and/or radiographic examinations supplemented by other nondestructive examinations are considered appropriate for this purpose.

If radiography is employed, the sources of radiation for examination of casting section less than two inches (50.8 mm) in thickness shall be from an X-ray generator or from Iridium 192 isotopes. The prototype evaluation shall demonstrate the ability of the casting procedure to consistently produce critical component casting soundness not less than the radiography standards of Table 1.

2) Production Castings

The method of nondestructive examination and the acceptance criteria for examination of the critical component production castings shall be established by the Manufacturer from consideration of material properties, environmental exposure, and stress level(s) in critical areas of the casting. The extent of the examination shall be adequate to assure castings possess soundness adequate for the intended purpose; i.e. examine all critically stressed areas.

3) Thermal Treatment

All castings for critical components shall be subjected to a normalize and temper, quench and temper, or stress relief heat treatment after shake out and cooling to ambient temperature.

The tempering and stress relief temperatures employed shall be appropriate to the alloy content and strength level required of the component, but shall not be less than 593°C (1100°F).

6.3.5 Bolting

Threaded fasteners subject to static and/or dynamic tensile loading (other than preload) employed in joining of critical components of the crane shall meet the requirement of ASTM A320/ A320M. The specific grade of material shall be selected to meet strength requirements, fracture toughness, and corrosion resistance of the service environment. Where bolting of higher strengths than permitted by ASTM A320/A320M is desired to be employed, the materials shall meet the specifications outlined in SAE Recommended Practice J 429. Qualification of the higher strength materials shall be by testing of two threaded fasteners from each heat of steel for proof of mechanical strength, hardness and Charpy impact energy values. The minimum average impact energy obtained from a set of three test shall be 40.6 Joules at minus 17.8°C with no single test value less than 29.8 Joules.

6.3.6 Plate

Critical structural elements fabricated from plate which must transfer loads through the thickness or the short transfers dimension of the plate shall be ultrasonically inspected in accordance with ASTM A578/A578M, Level II quality, and shall be tested for resistance to lamellar tearing in accordance with the procedures and requirements of ASTM A770/ A770M.

**TABLE 1 - ACCEPTANCE CRITERIA BASED ON ASTM RADIOGRAPHIC STANDARDS
(MAXIMUM ACCEPTABLE SEVERITY)**

TYPE OF DISCONTINUITY	ASTM E 446	ASTM E 186	ASTM E 280
Category A (gas porosity)	Serverity level 3	Severity level 2	Serverity level 2
Category B (sand and slag)	Serverity level 2	Serverity level 2	Serverity level 2
Category C (shrinkage)	Type CA, level 2 Type CB, level 2 Type CC, level 1 Type CD, level I	Type 1, level 1 Type 2, level 2 Type 3, level 1	Type 1, level 1 Type 2, level 1 Type 3, level 1

All discontinuities D, E, F and G are unacceptable.

6.4 Welding of Critically Stressed Components

6.4.1 General

All welding procedures for joining of structural load bearing or load transfer members of the crane and the performance of welders employing these procedures shall be qualified in accordance with a recognized standard such as the American Welding Society Specification for Welding Earthmoving and Construction Equipment, AWS D14.3/D14.3M, the American Welding Society Structural

Welding Code.

AWS D1.1/D1.1M, or the American Society of Mechanical engineers Boiler and pressure vessel Code, Section IX, Welding and Brazing Qualification.

6.4.2 Welding procedures

A written procedure specification shall be prepared for all welding. Prequalified procedures as defined in AWS D1.1/D1.1M and AWS D14.3/D14.3M are acceptable only for joining the materials using the consumables, joint configurations, and procedure limits specified therein. The welding of materials or use of procedures other than those defined by the AWS specification shall be qualified by testing a sample weld produced in accordance with a written procedure and tested in accordance with one of the standard listed in paragraph 6.4.1.

6.4.3 Welder performance

The performance of welders shall be verified by actual destructive testing or alternatively by radiographic examination.

Radiographic examination shall be limited to groove welds using the shielded metal arc, submerged arc, gas tungsten arc, gas metal arc (globular arc, spray arc or pulsating arc only) and flux cored arc processes. The performance of welder employing short-circuiting (short arc) gas metal arc welding processing shall be qualified by destructive testing only.

6.4.4 Welding properties

The strength and fracture toughness of welds and heat affected zones in critical components shall meet the minimum design specification requirements of the materials being joined. Mechanical testing shall be conducted during procedure qualification to verify the required proportions of the weld and heat affected zones are attained by the controls outlined in the welding procedure specification.

6.5 Non-Destructive Examination Components

6.5.1 Non-destructive examination procedures

The manufacturer shall establish written nondestructive examination procedures for the examination of critical structural components of the crane.

The procedures shall consider the stage of manufacture in which the examination is to be performed, the accessibility to examination methods, and the configuration of the component to be examined. These procedures shall be employed by the manufacture's personnel and/or any contract nondestructive examination personnel utilized by the manufacturer. The acceptance criteria on radiographic examination shall be as indicated in Table 1.

6.5.2 Minimum extent of non-destructive examination

The Manufacturer shall identify all critical components of the crane. These components shall be subjected to nondestructive examinations in accordance with a recognized workmanship standard or at the option of the Manufacturer by a written examination procedure and acceptance criteria developed in a fitness for purpose fracture control plan. The extent of nondestructive examination of noncritical components is also the responsibility of the Manufacturer.

6.6 Stability

6.6.1 Verification of stability

6.6.1.1 General

Calculations shall be made to verify that the crane is stable under the conditions specified in 6.6.1.2 and 6.6.1.3.