1. Welcome & Introductions

The new chairman of SC2, George Rodenbusch, opened the meeting. Andy Radford introduced himself as the new API Staff for SC2. Introductions were made and an Attendance Roster was circulated (see Attachment 1).

2. Fire & Blast

Fire and Blast design considerations are covered in Section 18 of RP 2A – it was included in Supplement to the 20th edition, but never really utilized by industry.

Once it became part of the “standard” in the 21st Edition, BP reviewed the content and felt that fire was covered well, but they did some additional work on the blast section of the standard to address the topsides and the hull.

BP has proposed that a Bulletin be produced on design for fire and blast design considerations to replace the content of Section 18 (see Attachment 2).

The group discussed the proposal, and there was general support for development of a separate RP to replace Section 18 of RP 2A. This approach would allow easier reference in other standards.

The proposed cost to update the content found in Section 18 with the additional information to be provided by BP is $58,000 (See Item 13.E below for discussion of funding mechanism).

The MMS is planning a Fire and Blast workshop in 2002, we want to have an API draft RP to help focus the discussions at the workshop.

3. Review of ISO 19902

API has contracted with Mustang Engineering ($20,000 contract/2000 money) to perform an editorial review of ISO CD 19902. This effort is underway, basically looking at the content of the ISO standard for consistency and completeness. The plan is to have comments on ISO CD ready for review by SC2 on October 15.

The ballot period for ISO CD 19902 ends on November 23. A copy of the CD is available at the following site: http://www.galbraithconsulting.co.uk/CD19902.PDF
4. **Comparison of 19902 to RP2A**

There is $50,000 in 2001 money available from API as seed money for a $300,000 JIP for a robustness study. Question: Is there support for this approach?

ISO would also like to do a robustness study, and therefore, there needs to be coordination between US and ISO efforts in this area.

One approach would be for a portion of the API money to be used to underwrite the promotion/solicitation for a JIP. This could be done for $10,000. The remaining $40,000 could then be reprogrammed to the Fire and Blast effort (see Item 13.E below). It is estimated that the JIP would need commitments of $300-500K to proceed.

If a worldwide robustness study is needed, the group felt a European engineering firm should be part of the study group.

On a related item, George Rodenbusch will look for volunteers to chair a TG to oversee this activity.

5. **Update of RP 2T**

Steve Leverette provided an update of TG activities (See Attachment 3). The TG last met in April to begin to develop the scope of their work. The next meeting is planned for August 29. A draft is expected by January.

6. **Update of RP 2RD**

Technology in 2RD is approaching 10 years in age. Industry experts feel that now would be a good time to look at updating the document. The preferred approach would be to have a contractor provide first draft of the update – estimated cost $60-70K. Another option is to work in conjunction with Deepstar. It was not on the current list of Deepstar proposals.

A draft proposal of what needs to be updated is expected this month. When available it will be distributed to SC2. Dave Wisch is coordinating this activity.

Andy Radford noted that RP 2RD is one of the deepwater priority standards, and he will explore the possibility of funding this project this year through the Deepwater Operations Steering Committee (DWOSC) and report back to Dave Wisch.

7. **Update of RP 2SK**

Tom Kwan provided an update of activities ongoing to update RP 2SK and other mooring standards (see Attachment 4). He highlighted some discrepancies between
API and DnV recommendations. A first draft is expected by end of 2001

8. **Review of Spec 2C**

API contracted an editorial review of standard. This work has been completed (see Attachment 5). There are some changes/additions needed to address dynamic aspects of cranes mounted on floating structures. SC2 would like to have the document updated to address dynamic considerations.

Paul Versowsky will approach Jean Leblanc about chairing a group to update the standard.

9. **Materials/Fabrications**

Peter Marshall updated the group on the activities of RG8 (see Attachment 6) the group has held 5 meetings since June 2000. Peter submitted a draft of 2MT2 for ballot (a copy of draft and a ballot will be sent to SC2 members following distribution of the minutes).

It was motioned, seconded, and passed (MSP) to submit the draft for letter ballot.

Peter noted that there was a need to update the steel tables in RP2A. there was some question as to whether this would result in a 22\textsuperscript{nd} edition of RP2A or a Supplement. It was MSP that RG8 develop the update to the steel tables and then SC2 could determine how to proceed on getting the information in RP 2A.

10. **Assessment**

Kris Digre reported that this group is not active. No activity anticipated until MMS takes regulatory action.

11. **Consequence-based Criteria**

It was reported that this group was not active.

12. **Hull/Structure Design**

Work on updating API Bulletin is ongoing, and a draft for ballot is expected in September.

13. **Any Other Business**

A. **Review of Rosters**

George Rodenbusch and Andy Radford will work to update the SC2 rosters.
B. RP2L

A request to update the document was made to Paul Versowsky. Paul agreed to chair the task group to review and update RP 2L. Please contact Paul if interested.

C. Publications

RP 2M – Tom Kwan reported that to his knowledge the standard is not being used. Tom Kwan will check with his TG to see if standard is needed and report back to George Rodenbusch with a recommendation for SC2 to ballot for reaffirmation or withdrawal.

RP2X – George Rodenbusch will check with Pete Sandy to get a recommendation on what should be done on this standard.

D. ISO Standards Update

See Attachment 7 for a chart with the current status of ISO SC7 offshore structure standards.

E. Prioritization of Funding Requests

SC2 discussed the 3 proposals for funding brought forward during the meeting as follows:

- Fire & Blast ($60,000) – top priority, fund by reprogramming $40,000 from the 2001 ISO 19902 robustness study money and attempt to get the remaining $20,000 from the API DWOSC. The desired outcome is the production of a Draft RP for use at the MMS workshop.
- ISO 19902 ($10,000) – The money remaining after reprogramming would be used to underwrite the promotion a JIP to conduct a robustness study of ISO 19902. Mustang Engineering will submit proposal regarding promotion of the JIP.
- RP 2RD – Funding for the update of this standard will be sought through the API DWOSC.

F. Next Meeting –

A tentative time frame of early February (preferably a Tuesday) was agreed.

14. Adjourn

The meeting adjourned at 2:00 pm.
<table>
<thead>
<tr>
<th>NAME</th>
<th>COMPANY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mike Spanhel</td>
<td>API - 202-682-8584 <a href="mailto:radforddav@gmail.com">radforddav@gmail.com</a></td>
</tr>
<tr>
<td>Andy Radford</td>
<td>SHELL 206-554-4124 <a href="mailto:gradenbusch@shell.com">gradenbusch@shell.com</a></td>
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</tr>
<tr>
<td>Girit C. Lee</td>
<td>504-788-5879 <a href="mailto:griff_c.lee@yahoo.com">griff_c.lee@yahoo.com</a></td>
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<td>Mike McLeod</td>
<td>Rowan, 713-960-7527, <a href="mailto:mike.mcLeod@rowan.comes.com">mike.mcLeod@rowan.comes.com</a></td>
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<td>DNV, 281 721 6169, <a href="mailto:carl.arne.carlsen@dnv.com">carl.arne.carlsen@dnv.com</a></td>
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<td>Consultant 713-432-2125, <a href="mailto:kwanc@fzuco.com">kwanc@fzuco.com</a></td>
</tr>
</tbody>
</table>

THIS FORM MUST BE RETURNED TO THE API STAFF TO SATISFY LEGAL AND REPORTING REQUIREMENTS ATTENDANCE RECORD IS REQUIRED FOR ALL API COMMITTEE MEETINGS

FOR API USE ONLY:
TOTAL COMMITTEE MEMBERS PRESENT:  
TOTAL API CORPORATE MEMBERS PRESENT:  
API MEMBER MEETING MAN DAYS:  

doc.attend
Proposal for API Research Funding
By P O’Connor

Committee: 2
Subcommittee: - 2
Date: May 19, 2001
Title: Design and Assessment of Offshore Structures For Fire and Explosion.

Objective:

To provide engineering guidelines for a harmonized approach for the design and assessment of offshore structures (fixed and floating) for fire and explosion. And to represent within the guidance present day technology and state-of-practice in the areas of fire and blast loading and resistance, which is consistent with modern practice in the associated fields of design safety and hazard identification and management.

Justification:

API RP2A Section 18 provides limited guidance for the design of fixed offshore structures for accidental loading including fire and blast. This guidance was published in 1997 in Supplement 1 of the 20th Edition of RP2A and more recently incorporated (without revision) into the main body of the 21st Edition. For floating systems no similar guidance is available and although recourse is often made to the UK Interim Guidance Notes, published in 1991, they also contain no explicit guidance for floating structures.

Recent and proposed major deepwater developments in the Gulf of Mexico and events elsewhere in the world have raised awareness of the importance of fire and explosion safety assessments for new and existing installations. Section 18 provides some guidance on the assessment of fixed platforms for fire and blast, however, the Exposure Categories defined therein were developed for assessment of risks associated with environmental loads (hurricanes) and are not appropriate for accidental loading due to the inability to evacuate ahead of the event. Two things are therefore required; (1) re-definition of Exposure Categories for fire and blast, which provide for appropriate safety assessments of higher-risk installations without penalty to existing and future low-risk installations and (2) Detailed guidance for the protection of offshore structures against fire and blast loading that represents modern best-practice and is applicable to all offshore structures.

The inclusion of Supplement 1 in the 21st Edition of API RP2A has come at a time when the Minerals Management Service (MMS) and the United States Coast Guard (USCG) are reviewing their respective regulatory roles. The result has been an increase in the responsibilities of MMS for offshore floating production systems. In response to this and to the realization that existing API guidance does not adequately provide for all structures the MMS has encouraged industry to support a major 2½-day International Workshop. The Workshop will be held in Houston on October 29-31, 2001 and is intended to provide a forum for wider industry to contribute towards a harmonized approach for the future design and assessment of offshore installations to resist fire and explosion hazards. The Workshop aims to establish present day technology and state-of-practice in the areas of design safety, hazard identification/management and fire and blast loading and resistance (including underpinning research).

The needs of industry, in particular with respect to deepwater and floating structures, are immediate. It is suggested that execution of the scope of work proposed herein combined with the input from industry through the planned Workshop and guidance from a re-convened API sub-committee for fire and blast can meet those needs in a timely and resource-efficient manner.

Approach:

STEP 1: Appoint a single contractor to prepare a Draft Bulletin based on existing work as follows:

In response to deepwater project requirements, BP America Inc. commissioned a contractor to develop internal Guidelines for the Protection of Offshore Structures against Fire and Explosion. BP is willing to release this document as a basis for the proposed API Bulletin. The document is based on the approach within API Section 18 but incorporates relevant content from the Interim Guidance Notes with updates to reflect modern best practice. The guidelines provide practical advice for engineers at a level appropriate for immediate use on deepwater projects. The document includes a comprehensive commentary, which covers fire load/response, explosion load/response, analysis methods and the interpretation of results. Combined fire and explosion load cases are also considered.
STEP 2: Implement industry views and feedback from the International Workshop for the ‘Harmonization of Future Design and Assessment of Offshore Installations for Fire and Explosion’.

STEP 3: Re-convene the API sub-committee for Fire and Explosion to review, comment, adjust and agree the content of the draft Bulletin.

The contractor responsible for writing the first draft should have intimate knowledge of the current provisions of API and the IGNs and understand the background and development of the BP Guidance document. The contractor should also have active involvement in the forthcoming International Workshop to capture wider industry input to the API Bulletin.

Scope of Work:

1. Re-convene the API Task Group for Fire and Blast.
2. Re-format the BP-donated base document as an API bulletin; include on-going critical updates, and distribute to Task group members for preliminary review and comment.
3. Receive wider-industry views and opinion from the Workshop in October 2001 and distribute (to Task Group members) proposed revisions to the Bulletin designed to accommodate the Workshop findings.
4. Conduct an API Task Group meeting to review and agree revisions to the first draft.
5. Update draft and conduct further API Task Group meetings until a final draft is developed and agreed.
6. Submit the final draft to API for balloting.

Deliverable:

API Bulletin for the Design and Assessment of Offshore Installations for Fire and Explosion.

Budget/Timing:

- Budget estimate $58,000
- Five months duration starting third quarter 2001.
API RP2T Workgroup Meeting
26 April 2001
Location: Marathon offices in Houston
Attendees:
  Gail Baxter, Marathon
  Shankar U. Bhat, Kellog Brown and Root
  Nyle Britton, Sea Engineering
  Richard Davies, CSO Aker
  Edward Huang, ABB
  Jafar Korloo, Unocal
  Tommy Laurendine, MMS
  Craig Lee, ABS
  Steve Leverette, Atlantia
  Ro Lokken, Exxon Mobil
  Ian Redfern, J. Ray Mcdermott
  John Wu, Texaco
Minutes by S. Leverette

Major Issues

• Limit States
  o Need to update load case table
  o Need to discuss nomenclature
    ▪ How it compares w/ISO, MMS, CFR30, CFR250
  o Operability
  o Ultimate (strength) extreme, reduced extreme
  o Survival (strength (PLS), configuration integrity)
  o Fatigue

• Response based criteria
  o Identify process in 2T

• 2T needs to be a global document ISO adoptable
• Maintain WSD as the basic premise with some sections possibly including
  LRFD type code equations.

Document Review Philosophy & Review all References

• Sections 1, 2, 3 were reviewed in the last meting

Section 4
• Needs to include more of
  o Design iterations
  o System & interface aspects
• Introduce response based approach
• Need to add SCR’s and fluid transfer lines, tender assist design (multi-body aspects), dry transport and field installed deck
• Guidance on regulatory compliance
• Expand and provide guidance on operating manuals

Section 5
• Add limit state definitions
• Revise stability section (3)
  o Clarity that hydrostatic stability is not an issue in place
  o Temporary conditions include inspection
  o Current discussion on minimum tension may need to be moved to another section
• Consider global performance response criteria (sub. Section 6)
• Env. Section needs to consider response based criteria
  o Ocean current coverage needs to be expanded

Section 5, Sub-section 6
• Extensive rework
• Add load case table
• Safety levels for damage cases
• Discussion of tendons as “structure” vs. “mooring”

Is there a need for loadcase tables in each section?

Section 6 – Loads / Forces
• Wind spectra update
• Ringing/impact/springing forcing
• Delete approximate methods or move to commentary
• Wave run up & inundation loads, column overtopping

Section 7 – Global Performance
• Implementation of response based criteria
• Changes to meet current practice in how loads are calculated
• Max & minimum tendon tension combination equations
• Coupled-body issues, coupled analyses w/riser, moorings
• Update VIV discussion + coupling into hull/deck structural modes including hull VIV response
• Include stress response based work - input to structure

Section 8 – Platform Structure
• Where does corrosion control belong? (include tendons/foundation/risers)
• Loadcases – how to get design waves/loads (such as matching hull structural loads w/max tendon tension loadcase)
• Delete space frame model??
• Refer to recognized class society
• Harmonize with 2V/2V
• Reflect 1, 3 or more columns
• Are we ready to use results of recent fatigue JIPs in RP2T?
  Design guidance on design details

Section 9 – Tendons
• Axial/bending/hoop compression interaction equations & safety factors
• Tendon fracture management philosophy (toughness, inspection leak – before break, life factors, “weak-link”, consequences)
• Update tendon VIV
• Recognize tendon alternative configurations & materials. (stepped, composite, pressured)
• Remove global analysis redundancy
• Fatigue combination methods
• Flex element fatigue methods (tearing energy)
• Mechanical component design (ISO)
• Recognize pre-installed tendons

Section 10 – Foundations
• Interact with API found work group
• Discuss single pile/tendon safety factors
• Suction-pile foundations
• Fatigue design practices for pile receptacles & welds during driving
• # of soil borings to define soil properties

Section 11 – Risers
• Address many aspects of risers, keel joints, SCRs, transfer lines
• Rely as much as possible on RP2D
• Riser clashing, allowable contact

Section 12 – Facilities
• MMS/USCG interactions (commentary)
• Primarily reference other RPs & RCS rules
• Hull/marine systems (hydrocarbons in hull?)
• Where is instrumentation discussed?
• Address issue of where to place referenced RP’s/STD’s/rules

Section 13 – Fabricate/Install/Inspect
• Need to tie fabrication tolerances to structural design assumptions
• Create new chapter for maintenance & in-service inspection
• Refer to RCS for inspection options
• Add transport (dry, float-off)

Section 14 – Materials
• Move to appropriate sections
Others:

**Weight Control** – consolidate: 5.3.4 - 8.2.8 - 12.2.3
- During design
- During operation
- Inclining

**Definition of Interfaces**
- Guidance - Systems Nature of TLP in planning section

**Corrosion Control**
- System nature
- High currents
- Throw of CP along tendon
- Refer to NACE, etc.
- Margins
- Uncoated voids

**Instrumentation (Planning?)**
- Interaction w/operations & fracture management philosophy
- Tank/void monitoring

**Schedule**
- Target draft to SC2 end summer 2002
- Good 1st draft end summer 2001

**Assignments - Table of Contents:**
1. Scope
2. References
3. Definitions and Terms
4. Planning
5. Criteria (add damage) Steve Leverette
6. Gloads and Forces George Gu
7. Global Performance Rick Mercier
8. Structure Gail Baxter/Edward Huang
9. Tendons Kent Davies/Nyle Britton
10. Foundation API Geotechnical (Doyle?)
11. Riser Shankar Bhat
12. Facilities (Topsides/hull/marine) (Aker?)
13. Fabrication/Installation/Inspection/Transportation Ian Redfern
14. Maintenance and Inspection Craig Lee

New areas:
- Weight Control
- Interfaces
- Corrosion
- Instrumentation
Next Meeting (in 6 weeks)
— Progress report
— Discuss major issues
  o Limit states / response based criteria
— Identify need for resources
Current Status of Mooring Codes

1. API RP 2SK
   • Third Edition to be issued in 2002-2003 (jointly funded by API and DeepStar)

2. ISO Mooring Code
   • Normative: hard requirements, including new criteria
   • Informative: reference to 2SK and other documents
   • To be published with other documents for floating structures under WG 5
   • Not expected to become official in the near future

3. API RP 2SM
   • Fiber rope mooring code
   • First Edition March 2001

4. API RP 2I
   • In-service mooring inspection for MODUs
   • Second Edition 1997

5. DNV Rules: Consequence Class, Partial FS
   • OS-E301 Posmoor
   • RP-E301 Fluke Anchors
   • RP-E302 Plate Anchors (VLA)
   • OS-C101 Suction Anchors

New areas that need to be covered
1. Coupled analysis (DeepStar CTR 5401)
2. Mooring system reliability (DeepStar CTR 4400)
3. Fiber rope inspection and discard criteria (MMS, DnV JIP)
4. Vertically loaded anchor/Suction anchor (API study?)
5. SEPLA (Suction Embedded Plate Anchor)
6. Other issues
Consequence Class 1

- Drilling units (Riser disconnected; 300m, or 1.5xW.D. away from other installation)
- Accommodation units at least 300m (or 1.5xW.D) away from other installation
- Production units with one production riser and well control umbilical
- Loading buoys in benign water

Consequence Class 2

- Drilling units (Riser connected)
- Drilling and accommodation units less than 50m away from other installation
- Production units with one production riser but without quick release
- Production units with several production risers, with control umbilical, producing
- Units positioned 50m-300m (or 1.5xW.D.) from other installation (for the mooring line pointing away from the installation)

Design Environment

- 100-year return period
DnV Draft Standard POSMOOR, July 2000

\[ S_C - T_{C\text{-mean}} \cdot \gamma_{\text{mean}} - T_{C\text{-dyn}} \cdot \gamma_{\text{dyn}} \geq 0 \quad S_C = 0.95 \quad S_{\text{mbs}} \]

**Table 3-1. Partial Safety Factors for ULS**

<table>
<thead>
<tr>
<th>Consequence Class</th>
<th>Type of analysis of wave frequency motion</th>
<th>Partial Safety factor on mean tension ( \gamma_{\text{mean}} )</th>
<th>Partial Safety factor on dynamic tension ( \gamma_{\text{dyn}} )</th>
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<tr>
<td>1</td>
<td>Dynamic</td>
<td>1.10</td>
<td>1.50</td>
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<tr>
<td>2</td>
<td>Dynamic</td>
<td>1.40</td>
<td>2.10</td>
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</table>

*DnV Equiv. FS API/ISO FS

1.37 1.67
1.82

**Table 3-2. Partial Safety Factors for ALS**

<table>
<thead>
<tr>
<th>Consequence Class</th>
<th>Type of analysis of wave frequency motion</th>
<th>Partial Safety factor on mean tension ( \gamma_{\text{mean}} )</th>
<th>Partial Safety factor on dynamic tension ( \gamma_{\text{dyn}} )</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Dynamic</td>
<td>1.00</td>
<td>1.10</td>
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<tr>
<td>2</td>
<td>Dynamic</td>
<td>1.00</td>
<td>1.25</td>
</tr>
</tbody>
</table>

1.11 1.25
1.18

*Assume equal dynamic and mean tension
Relative Contribution of Mean, Low Frequency, and Wave Frequency Tensions to Total Tension, for Critical Environmental Cases
API RP 2SK Work Group Kickoff Meeting

Date: June 14, 2001
Attendee: Tom Kwan, Peter Poranski, C. H. Luk, Subir Bhattacharjee, David Smith, Paul Devlin, Craig Kolby, Ming-Yao Lee, David Tein, Ben Cole, Ken Huang, Hongbo Shu, Yong Luo, Hans Treu.

Major Decisions:

1. The industry is not ready to move in DnV’s direction. API RP 2SK will still use the total factor of safety approach without defining consequence classes.

2. Hans Treu of CSO Aker will take a lead to develop a draft on a design guide for suction and plate anchors. Results of API funded research “Deepwater Anchor Design Research” will be incorporated when available.

3. Decision for combining mooring codes is:

   New API RP 2SK
   • Old API RP 2SK
   • ISO Mooring Code (design part)
   • Coupled analysis (DeepStar CTR 5401)
   • Mooring system reliability (DeepStar CTR 4400)
   • Vertically loaded anchor/Suction anchor (API study?)
   • SEPLA (Suction Embedded Plate Anchor)
   • Other issues

   API RP 2SM (unchanged)

   New API RP 2I
   • Old API RP 2I
   • Fiber rope discard criteria (MMS, DnV JIP)
   • ISO Mooring Code (inspection part)
Attached is the draft of the subject document.

API is getting a bonus on this job. The document required considerable review, reorganization, and editing. I found out that my editing style works much better when I have a document I can work with. Therefore, I scanned the document into Word format and made the changes. There is no charge for the scanning of the document.

Some changes you need to be aware of:

1. The format was changed to reflect that found in the most recent API documents.
2. The Table of Contents was changed to reflect the new organization.
3. There is a new Section 2 that references standards used or useful publications that the reader may want to review.
4. The full titles of referenced standards are in footnotes. Some titles were in the text but most standards were referred to by number only. There are so many standards that they get distracting when the full titles are placed in the text.
5. The Appendix B references are in footnotes. I added a new paragraph (1.4) at the front of the document that explains the organization of Appendix B and how it tracks the text. The same explanation was added at the beginning of Appendix B.
6. The word “federal” was changed to “national” to improve the international scope.
7. The words listed in the definition section were reduced to those that are in the text of the publication.
8. A section on acronyms was added.

I have reviewed the dates of all the standards reference but did not put the actual date of the latest revision in the document. I can supply the dates if you decide you want to put the dates into the references. Many are going to change shortly so I don’t know if you want to date them or tell the reader to look for the latest edition. For example, AISC is claiming they will have a new document late this year.

After you look it over, let me know if you need something else done to it or have questions.

Danny R. Rycroft
Rycroft Enterprises
SPECIAL NOTES

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and national laws and regulations should be reviewed.

API is not undertaking to meet the duties of employers, manufacturers, or suppliers to warn and properly train and equip their employees, and others exposed, concerning health and safety risks and precautions, nor undertaking their obligations under local, state, or national laws.

Information concerning safety and health risks and proper precautions with respect to particular materials and conditions should be obtained from the employer, the manufacturer or supplier of that material, or the material safety data sheet.

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FOREWORD

This Specification is under the jurisdiction of the API Committee on Standardization of Offshore Structures.

The purpose of this Specification is to provide standards for the offshore cranes suitable for use in drilling and production operations.

This standard shall become effective on the date printed on the cover but may be used voluntarily
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Suggested revisions are invited and should be submitted to the Director, Upstream Department, 1220 L Street, N.W., Washington D.C. 20005.

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Specification for Offshore Cranes

Section 1—Scope

1.1 This Specification 2C details the requirements for design, construction, and testing of pedestal mounted elevating and rotating lift devices of the types illustrated in Figure 1 for transfer of materials or personnel to or from marine vessels and structures. Specification 2C is not intended to be used for the design, fabrication, and testing of davits, and/or emergency escape devices.

1.2 Included are methods for establishing rated loads based on allowable unit stresses for load supporting components, as differentiated from power transmitting mechanisms. Also included are minimum requirements for equipment, materials, manufacturing procedures, and testing.

1.3 STRUCTURAL COMPONENTS

Structural components covered by this Specification 2C are listed below, including some shown in Figure 1. Appendix A contains some examples of critical structural components.

a. Crane boom
b. Boom point sheave assembly
c. Boom-tip extension or jib
d. Floating harness or bridle
e. Gantry, Mast or A-frame
f. Revolving upper-structure
g. Swing-circle assembly
h. Boom foot pin(s)
i. Sheave pin(s)
j. Boom splice bolts or connectors
k. Foundation bolts or fastenings
l. Pedestal or base
m. King post or Center Post

1.4 COMMENTARY

Further information and references on various topics contained in this Specification 2C are included in the Commentary found in Appendix B. The paragraph numbers in Appendix B correspond to the paragraph numbers of this Specification 2C. For example, paragraph 4.1 of the Specification 2C, entitled Rated Load, corresponds to paragraph B.4.1 of the Commentary, entitled Rated Load, in Appendix B.
1.5 RECORD RETENTION
The manufacturer shall maintain all inspection and testing records for 20 years. These records shall be employed in a quality audit program of assessing malfunctions and failures for the purpose of correcting or eliminating design, manufacturing, or inspection functions, which may have contributed to the malfunction or failure.

Section 2—REFERENCES
2.1 STANDARDS
The following standards contain provisions, which through reference herein, constitute provisions of this standard. All standards are subject to revision with several standards organizations indicating that revisions are scheduled as this is written. Users are encouraged to search for the most recent editions of the standards indicated below:

**American Bearing Manufacturers Association (ABMA)**
- ABMA Std. 9 Load Ratings and Fatigue Life for Ball Bearings
- ABMA Std. 11 Load Ratings and Fatigue Life for Roller Bearings

**American Bearing Manufacturers Association (ABMA)**
- ANSI/AGMA 6010-F97 Standard for Spur, Helical, Herringbone and Bevel Enclosed Drives
- ANSI/AGMA 2001-C95 Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth
- AGMA 908-B89 Information Sheet – Geometry Factors for Determining the Pitting Resistance and Bending Strength of Spur, Helical, and Herringbone Gear Teeth

**American Institute of Steel Construction (AISC)**
- Specification for the Design, Fabrication and Erection of Structural Steel for Buildings

**American National Standards Institute (ANSI)**
- ANSI 14.3 Ladders-Fixed-Safety Requirements
- ANSI A 1264.1 Safety Requirements for Workplace Floor and Wall Openings, Stairs, and Railing Systems
- ANSI B18.2.1 Square and Hex Bolts and Screws (Inch Series)

**American Petroleum Institute (API)**
- API-2D Recommended Practice for Operation and Maintenance of Offshore Cranes
- API-2H Specification for Carbon Manganese Steel Plate for Offshore Platform Tubular Joints
- API-2X Recommended Practice for Ultrasonic and Magnetic Examination of Offshore Structural Fabrication and Guidelines for Qualification of Technicians
- API-9A Specification for Wire Rope
2.2 OTHER REFERENCES

The following standards and specifications contain useful information.

American Society of Mechanical Engineers

HST-4: Performance Standard for Overhead Electric Wire Rope Hoists

ASME Boiler and Pressure Vessel Code, Section V—Nondestructive Examination
Section 3—Definitions and Acronyms

3.1 DEFINITIONS

"a"-frame: See "GANTRY" also called "MAST." (Ref Figure 1, Item 18)
auxiliary hoist: See "WHIP LINE." (See Figure 1, Item 27)
axis of rotation: The vertical axis around which the crane upper-structure rotates.
base (mounting): See "PEDESTAL" (See Figure 1, Item 24)
bearing raceway: The surface of the bearing rings which contact the rolling element (balls or rollers) of the swing bearing assembly. (See Figures 6 & 7)
bearing ring: The rotating and stationary rings that house the rolling elements (balls or rollers) of the swing bearing assembly. (See Figures 6 & 7)
boom: A member hinged to the revolving upper-structure and used for supporting the hoist tackle.
boom angle: The angle above or below horizontal of the longitudinal axis of the base boom section.
boom chord: A main corner member of a lattice type boom. (See Figure 1, Item 1)
boom extension: Intermediate section of a telescoping boom. (See Figure 1, Item 2)
boom foot-pin: The boom pivot point on the upper-structure. (See Figure 1, Item 3)
boom hoist: See paragraph 8.2 and its subparagraphs.
boom hoist mechanism: Means for supporting the boom and controlling the boom angle. (See Figure 1, Item 4)
boom hoist wire rope: Wire rope that operates on a drum controlling the angle positioning of the boom. (See Figure 1, Item 5)
boom lacing: Structural truss members at angles to and supporting the boom chords of a lattice type boom. (See Figure 1, Item 6)
boom length: The straight-line distance from the centerline of boom foot-pin to the centerline of the boom-point load hoist sheave pin, measured along the longitudinal axis of the boom.
boom lift-cylinder: Means for supporting the boom and controlling the boom angle. (See Figure 1, Item 7)

boom line: Boom hoist rope that reels on drums or passes over sheaves. See Boom Hoist Wire Rope.

boom-point sheave assembly: An assembly of sheaves and a pin built as an integral part of the boom-point. (See Figure 1, Item 8)

boom splices: Splicing connections for sections of basic crane boom and additional sections usually of the splice plate type, pin type, or butt type. (See Figure 1, Item 12)

boom stop: A device used to limit the angle of the boom at the highest recommended position. (See Figure 1, Item 13)

boom-tip extension: See "JIB." (See Figure 1, Item 14)

brake: A device used for retarding or stopping motion or holding.

bridle: See "FLOATING HARNESS." (See Figure 1, Item 17)

cab: An enclosure for the operator and the machine operation controls. (See Figure 1, Item 15)

clutch: A means for engagement or disengagement of power.

counterweight: Weight used to supplement the weight of the machine in providing stability for lifting working loads and usually attached to the rear of the revolving upper-structure. (See Figure 1, Item 16)

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. See examples in Appendix A of this Specification.

designated: Selected or assigned by the employer or the employer's representative as being qualified to perform specific duties.

design load: See Paragraph 5.1.2 of this Specification.

design requirements: The requirements set forth by the manufacturer's engineering authority for materials, manufacturing, fabrication, and inspection procedures to be employed in the production of the crane.

dynamic loading: Loads introduced into the machine or its components due to accelerating or decelerating loads.

enclosure: A structure that may provide environmental protection for the machine.

fitness-for-purpose: The manufacture or fabrication of an assembly or component to the quality level required (but not necessarily the highest level attainable) to assure material properties, environmental interactions, and any imperfections present in the assembly or connection are compatible with the intended purpose. Fitness-for-purpose connotes an assembly or component may contain material or fabrication imperfections of sizeable dimensions but their presence has no influence on its performance or reliability.

floating harness (Also known as BRIDLE): A frame equipped with sheaves and connected to the boom by stationary ropes usually called pendants. (See Figure 1, Item 17)
foundation bolts or fasteners: The bolts used to connect a swing bearing to the upper-structure and/or pedestal.

fracture control plan: The consideration of material properties, environmental exposure conditions, potential material and fabrication imperfections, and methods of inspection for the purpose of eliminating conditions which could result in failure under the design requirements for the projected life of the crane.

gantry (Also known as "A" FRAME): A structural frame, extending above the upper-structure to which the boom support ropes are reeved. (Ref Figure 1, Item 18)

guy rope: A non-operating, standing wire rope that maintains a constant distance between the points of attachment to the components connected by the wire rope.

hoisting: The process of lifting.

hoist mechanism: A hoist drum and rope reeving system used for lifting and lowering loads.

hoist rope: Wire rope involved in the process of lifting.

hoist tackle: Assembly of ropes: and sheaves arranged for pulling.

hook block: Block with a hook attached used in lifting service. It may have a single sheave for double or triple line or multiple sheaves for four or more parts of line. (See Figure 1, Item 19)

hook rollers: Rollers that prevent the lifting of the revolving upper-structure from the roller path. Hook rollers are a means to connect the upper-structure to the foundation or pedestal.

jib (Also known as TIP EXTENSION): An extension attached to the boom point to provide added boom length for lifting specified loads. (See Figure 1, Item 14)

king-pin: Vertical pin or shaft that acts as a rotation-centering device and connects the revolving upper-structure and base mounting.

king post: A tubular member that acts as the centerline of rotation and as the connective member to the platform. (See Figure 1, Item 20)

lacing: See "BOOM LACING " (See Figure 1, Item 6)

load block—lower: The assembly of hook or shackle, swivel, sheaves, pins, and frame suspended by the hoisting ropes.

load block—upper: The assembly of shackle, swivel, sheaves, pins, and frame suspended from the boom point.

load line (Also known as "hoist line"): In lifting crane service it refers to the main hoist. (See Figure 1, Item 22) The secondary hoist is referred to as a "WHIP LINE or AUXILIARY LINE." (See Figure 1, Item 28)

load ratings: Crane ratings in, pounds (kilograms, decanewtons) established by the manufacturer in accordance with Section 4.

loose gear: Loose gear includes all slings, nets, hooks, baskets, shackles, chains, ropes, cables, life vests, etc., necessary in crane operations to attach the load to the crane hook or block and to move the load. (Life jackets and life vests are terms for a Coast Guard approved life saving device able to support an unconscious person in the face-up position. Work vests are buoyant flotation devices, usually made of plastic and foam. Work vests are not approved for work over water or for personnel transfer.)

luffing: The operation of changing boom angle in a vertical plane.
main hoist line: See "LOAD LINE." (See Figure 1, Item 22)

major structural revision: A change to the structure that reduces the load-carrying capability of any structural component or for which a revised load chart has been established.

mast (Also known as GANTRY): A frame hinged at or near the boom hinge for use in connection with supporting a boom. The head of the mast is usually supported and raised or lowered by the boom hoist ropes.

operator's station: The designated location for the operator to operate the machine.

overhaul: Ability of a weight on the end of the hoist line to unwind rope from the drum when the brake is released.

overhaul ball: The weight on a single part line used to pull the wire rope off the drum with gravitational assistance. (See Figure 1, Item 23)

pawl (dog): A device for positively holding a member against motion in one or more directions.

pedestal (Also known as BASE): The supporting substructure upon which the revolving upper-structure is mounted. (See Figure 1, Item 24)

pendant (Also known as GUY ROPE): A non-operating standing rope of specified length with fixed end connections. (See Figure 1, Item 25)

pitch diameter: Root diameter of drum, lagging or sheave, plus the diameter of the rope. (See Figures 3 and 5)

power controlled lowering: A system or device in the power train, other than the load hoist brake, that can control the lowering speed of the load hoist mechanism.

prototype: An initial manufactured component or unit of a specific design adhering to this edition of API Specification 2C.

qualified: A person who, by possession of a recognized degree, certificate of professional standing, or who by extensive knowledge, training, and experience, has successfully demonstrated the ability to solve or resolve problems relating to the subject matter and work.

rated capacity: The rated load at specified radii as established by the manufacturer and are the maximum loads at those radii covered by the manufacturer's warranty.

reeving: A rope system where the rope travels around drums and sheaves.

revolving upper-structure: The rotating upper frame structure and the operating machinery mounted thereon.

ring gear: See "SWING GEAR." (Also called BULL GEAR)

roller path: The surface upon which the rollers that support the revolving upper-structure bear. It may accommodate cone rollers, cylindrical rollers, or live rollers.

rolling element: The balls or rollers contained between the rings of the swing-circle bearing. (See Figures 6 & 7)

rotating base: See "REVOLVING UPPER-STRUCTURE."

rope: Refers to wire rope unless otherwise specified.
rotation-resistant rope: A wire rope consisting of an inner layer of strand laid in one direction covered by a layer of strand laid in the opposite direction. This has the effect of counteracting torque by reducing the tendency of the finished rope to rotate.

shall: This word indicates that the rule is mandatory and must be followed.

should: This word indicates that the rule is a recommendation, the advisability of which depends on the facts in each situation.

sideload: A load applied at an angle to the vertical plane of the boom.

sling: An assembly that connects the load to the material handling equipment.

standing (guy) wire rope: A supporting, non-operating wire rope that maintains a constant distance between the points of attachment to the two components connected by the wire rope.

structural competence: The ability of the machine and its components to withstand the stresses imposed by applied loads.

swing (slewing): Rotation of the upper-structure for movement of loads in a horizontal direction about the axis of rotation.

swing bearing: A combination of rings with balls or rollers capable of sustaining radial, axial, and moment loads of the revolving upper-structure with boom and load.

swing-circle assembly: (See Figure 1, Item 26)

swing-circle: See "SWING BEARING" and "ROLLER PATH."

swing gear (Also known as RING GEAR or BULL GEAR): External or internal gear with which the swing pinion on the revolving upper-structure meshes to provide swing motion.

swing mechanism: The machinery involved in providing dual directional rotation of the revolving upper-structure.

swivel: A load-carrying member with thrust bearings that permit rotation under load in a plane perpendicular to the direction of the load.

swivel: The rotation of the load attachment portion (hook or shackle) of a load block (lower) or hook assembly about its axis of suspension in relation to the load line(s).

tail swing (rear end radius): Clearance distance from the center of rotation to the maximum rear extension of the revolving upper-structure.

telelescoping boom: Consists of a base boom from which one or more boom sections are telescoped for additional length. (See Figure 1, Type B, Items 2, 10, 11)

torque converter: Auxiliary transmission connected to the prime mover that multiplies engine torque as load increases with a corresponding decrease in speed.

two-blocking: The condition when the lower load block or hook assembly contacts the upper load block or boom-point sheave assembly.

upper-structure: See "REVOLVING UPPER-STRUCTURE."

whipline: A secondary rope system, usually of lighter load capacity than provided by the main rope system. Also known as "AUXILIARY." (See Figure 1, Items 27 and 28)

wire rope: A flexible, multi-wired member usually consisting of a core member around which a number of multi-wired strands are "laid" or helically wound.
working load: The external load in pounds (kilograms, decanewtons), applied to the crane including the weight of load-attaching equipment such as load block, shackles, and slings.

3.2 ACRONYMS

The following acronyms are used in this publication:

- ABMA American Bearing Manufacturers Association
- AGMA American Gear Manufacturers Association
- AISC American Institute for Steel Construction
- ANSI American National Standards Institute
- API American Petroleum Institute
- ASME American Society of Mechanical Engineers
- ASNT American Society of Nondestructive Testing
- ASTM American Society of Testing and Materials
- AWS American Welding Society
- ISO International Standards Organization
- SAE Society of Automotive Engineers

Section 4—Crane Rating

4.1 RATED LOAD

Ratings shall be established for static and dynamic loadings.

4.1.1 Static Rated Load

Static rated load\(^1\) shall be that load which can be lifted quasi-statically when no relative motion exists between the crane and the load to be lifted. Static ratings shall be established for lifting from, or setting on, the crane-supporting structure. The static rated load shall be the least of the following:

- a. 75% of the "Category 1 Design Load."
- b. Maximum load based on load line reeving and wire rope design factors in accordance with paragraph 7.2 of this Specification 2C and its subparagraphs.
- c. Maximum load based on load hoist line pull available, considering line reeving losses with manufacturer's design reeving, for a load at the boom head, calculated in accordance with paragraph 8.1.8 of this Specification 2C.
- d. Maximum load based on boom line reeving and wire rope design factors in accordance with paragraph 7.2 of this Specification 2C and its subparagraphs.
- e. Maximum load based on boom pendant wire rope in accordance with paragraph 7.2 of this Specification 2C and its subparagraphs.
- f. 75% of maximum load based on boom hoist line pull available, considering line reeving losses with manufacturer's design reeving for boom line, calculated in accor-

\(^1\) For more information, see Appendix B—Commentary, paragraph B.4.1.1, Static Rated Load
dance with paragraph 8.1.8 of this Specification 2C.

The published "load chart" rated load shall be reduced from the above calculated rated loads by the weight of the hook and block excluding the load hoist rope.

4.1.2 Dynamic Rated Load

The dynamic rated load\(^1\) shall be that load which can be lifted under specified dynamic conditions encountered when relative motion exists between the crane and the load to be lifted. Dynamic ratings shall be established for lifting from or setting on vessels. The dynamic rated load shall be the least of the following:

a. The "Category 2 Design Load" divided by the applicable dynamic coefficient \((C_b\) or \(C_f\)) from paragraph 4.2 of this Specification 2C and its subparagraphs.

b. Maximum load based on load line reeving and wire rope design factors in accordance with paragraph 7.2 of this Specification 2C and its subparagraphs.

c. Maximum load based on load hoist line pull available, considering line reeving losses with manufacturer's design reeving, for a load at the boom head, calculated in accordance with paragraph 8.1.8 of this Specification 2C.

d. Maximum load based on boom line reeving and wire rope design factors in accordance with paragraph 7.2 of this Specification 2C and its subparagraphs.

e. Maximum load based on boom pendant wire rope in accordance with paragraph 7.2 of this Specification 2C and its subparagraphs.

f. 75\% of maximum load based on boom hoist line pull available, considering line reeving losses with manufacturer's design reeving for boom line, calculated in accordance with paragraph 8.1.8 of this Specification 2C.

The published "load chart" rated load shall be reduced from the above calculated rated loads by the weight of the hook and block excluding the load hoist rope.

4.1.3 Design Load

To help determine allowable crane loadings, a design load shall be used. The design load is the product of the rated load times the applicable load factor or dynamic factor. Therefore, the design load is the load the crane will see when the rated load is lifted and the design dynamic levels are acting on this load. A Category 1 Design Load as defined in Section 5 of this Specification 2C shall be the static rated load times a load factor of 1.33. A Category 2 Design Load as defined in Section 5 of this Specification 2C shall be the dynamic rated load times the applicable dynamic load factor. The design loads are used in subsequent sections to define the required safety factors and design criteria for the crane components.

4.1.4 Personnel Rated Load

When handling personnel the rated load shall be the least of the following:

a. 25\% of the "Category 1 Design Load."

b. Maximum load based on load line reeving and wire rope design factors per paragraph 7.2 of this Specification 2C and its subparagraphs.

c. Maximum load based on load hoist line pull available, considering line reeving losses with the manufacturer's design reeving, for a load at the boom head, calculated in

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\(^1\) For more information, see Appendix B—Commentary, paragraph B.4.1.2, Dynamic Rated Load
accordance with paragraph 8.1.8 of this Specification 2C.

The published "load chart" rated load shall be reduced from the above calculated rated loads by the weight of the hook and block excluding the load hoist rope. The personnel net shall be considered part of the load.

4.2 DYNAMIC COEFFICIENTS

4.2.1 Bottom-Supported Structures

Dynamic coefficients for cranes mounted on bottom-supported or floating structures shall be determined by the crane manufacturer as set out below.

4.2.1.1 When the purchaser supplies the specific Significant Wave Height(s), \( H_{\text{sig}} \), the associated dynamic coefficient \( C_b \) shall be determined by the following equation:

\[
C_b = 1 + (V_h + V_d) \left( \frac{K}{gL} \right)^{1/2}
\]

but not less than 1.33.

Where:

\( H_{\text{sig}} \) = Significant Wave Height—ft (m). It is intended that the purchaser provide the manufacturer with the Significant Wave Height(s) for which Dynamic Rated Load Charts are required.

\( C_b \) = Dynamic Coefficient for a bottom-supported structure

\( V_h \) = Absolute vertical velocity of the hook—ft/sec (m/sec)

\( V_d \) = Absolute vertical velocity\(^1\) of the cargo deck at the pick point—ft/sec (m/sec).

\( V_d = 0.6 \, H_{\text{sig}} \) for \( 0 < H_{\text{sig}} < 9.8 \) ft (3 m)

\[ \text{or:} \]

\( V_d = 1.8 + 0.3 \, (H_{\text{sig}} - 3) \) m/sec for \( H_{\text{sig}} > 3 \) m

\( V_d = 5.9 + 0.3 \, (H_{\text{sig}} - 9.8) \) ft/sec for \( H_{\text{sig}} > 9.8 \) ft

\( K \) = Vertical spring rate of the crane at the hook—lb/ft (N/m)

\( g \) = Acceleration due to gravity—32.2 ft/sec\(^2\) (9.81 m/sec\(^2\))

\( L \) = Lifted Load-lb (N) which is an unknown and therefore will require iteration to obtain \( C_b \). A good starting value for \( L \) is one-half the Category 2 Design Load.

4.2.1.2 Alternative deck velocities, offlead, and sidelead conditions may be specified by the purchaser in lieu of using those defined in paragraph 4.2.1.1 above. These should be site-specific estimates based on dynamic operating conditions, sea state, etc.

4.2.1.3 In the absence of a specified Significant Wave Height from the purchaser, offlead, sidelead, and wind forces shall be taken as zero, and the dynamic coefficient shall be taken as 2.0. This condition is considered appropriate only in situations where the supply boat position is maintained such that movements, which would induce significant sidelead and offlead forces to the crane hoisting system, are minimized.

4.2.1.4 Unless otherwise agreed to by the purchaser, the crane should be equipped to provide a minimum available hook speed \( (V_{\text{min}}) \) with the hook positioned at the supply boat

\(^1\) For more information, see Appendix B—Commentary, paragraph B.4.2.1, Bottom-Supported Structures
deck when lifting the maximum rated dynamic load and reeved as specified in the load rating chart.

\[ V_{min} = 0.1 (H_{sig} + 1) - \text{m/sec} \]

\[ V_{min} = 19.7 (0.304 H_{sig} + 1) - \text{feet/minute; but not less than 40 ft/min (0.2 m/sec).} \]

For the effects of offlead, sidelead, and wind speed, see paragraph 5.1.2.2 below.

4.2.2 Floating Structures

The purchaser shall supply the specific crane operating conditions including offlead, sidelead, wind speed, and relative vertical velocity\(^1\) of the cargo deck to the crane boom point for each desired rating condition. The dynamic coefficient \((C_f)\) shall be determined by the following equation:

\[ C_f = 1 + (V_H + V_R) (K/gL)^{1/2} \]

but not less than 1.33.

Where:

- \(C_f\) = Dynamic Coefficient—Floating Structure
- \(V_H\) = Absolute vertical velocity of the hook—ft/sec (m/sec)
- \(V_R\) = Relative vertical velocity of the cargo deck at the pick point to the crane boom point—ft/sec (m/sec) See Appendix B (Commentary)
- \(K\) = Vertical spring rate at the hook—lb/ft (N/m)
- \(g\) = Acceleration due to gravity 32.2 ft/sec\(^2\) (9.81 m/sec\(^2\))
- \(L\) = Lifted Load—lb (N); which is an unknown and therefore will require iteration to obtain \(C_f\). A good starting value for \(L\) is one-half the Category 2 Design Load.

For the effects of offlead, sidelead, and wind speed, see paragraph 5.1.2.2 above.

4.3 LOAD RATING CHART

A substantial and durable rating chart(s) with clearly legible letters and figures shall be provided with each crane and securely fixed to the crane in a location easily visible to the operator. The chart(s) shall provide the following information:

1. The manufacturer's approved load ratings, at operating radii not exceeding 5.0 ft (1.5 meter) increments, and corresponding boom angles down to horizontal for the specified boom length and jib length, where applicable.
2. The basis of ratings and certification of compliance with this Specification 2C.
3. Reeving diagrams or charts recommending the number of parts of line for each load and the size and type of each load rope used on the crane. These diagrams or charts can be shown either on the chart or by chart reference to the specific crane's operating manual.
4. Precautionary or warning notes relative to limitations on equipment and operating procedures.

Section 5—Structural Competence Established by Stress

\(^1\) For more information, see Appendix B—Commentary, paragraph B.4.2.2, Floating Structures
Analysis

5.1 ANALYSIS

All critical\(^1\) structural components (except as noted in paragraph 5.1.3 below) shall be designed to conform with the allowable unit stresses specified in the AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings, latest edition, when subjected to dead load, plus the design and horizontal loads defined in paragraph 5.1.2 and its sub-paragraphs of this Specification 2C.

Pedestals and king posts shall be designed for the maximum of:

1. dead load plus 1.5 times Category 1 Design Load, or
2. dead load plus 1.5 times Category 2 Design Load.

The effects of wind, sidelead, and offlead associated with these loads shall be included in the design.

For structural steels other than those listed in the AISC Specification, compatibility with the AISC allowable unit stresses should be established and documented.

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 the AISC Specification.

5.1.1 Application of Loads

For purposes of analysis, vertical and horizontal loads shall be applied to the crane statically, assuming the crane is level (a true vertical swing axis). For cranes mounted on floating structures, the effect of pitch, heave, and roll on the crane shall be translated into offlead and sidelead angles of the load line with respect to the crane boom. In this way, the ratio of horizontal sideload to vertical load is computed as the tangent of the sidelead angle, and similarly for the offlead condition.

5.1.2 Design Load

During rating calculations for a known crane configuration, "design load" will be the basic unknown quantity to be determined. However, during the actual sizing of structural components, the design loads can be stated in terms of desired rated loads as set out below:

1. For static conditions, the design load supported vertically from the boom point will be 1.33 times the desired static rated load and would be applied simultaneously with a horizontal side load equal to 2% of the vertical design load plus dead load.

2. For dynamic conditions, the governing design load supported vertically at the boom point will be the dynamic coefficient \(C_f\) or \(C_b\) (from paragraph 4.2 of this Specification 2C and its subparagraphs) times the desired dynamic rated load. The controlling design load shall be applied with its corresponding horizontal loads plus dead load.

For the boom, the governing design load will likely be dictated by the desired dynamic rated load (because of the horizontal loads), whereas the sizing of all other components will likely be governed by 1.33 times the desired static rated load.

The design load applicable for static ratings (termed Category 1) and for dynamic rating (termed Category 2) shall be as set out below.

\(^1\) See definition of critical in Section 3 and see Appendix A: Example List of Critical Components
5.1.2.1 Category 1 Design Load — This design load shall be the load that can be suspended vertically from the boom point simultaneously with 2.0% of this design load applied as a horizontal side load to the boom head sheave pin, plus dead load, without exceeding the AISC allowable unit stresses. It is important to point out that although the above loads are applied simultaneously they are independent of each other, e.g., the vertically suspended design load (Category 1 Design Load) does not include dead load.

5.1.2.2 Category 2 Design Load — This design load shall be the load that can be suspended vertically from the boom point simultaneously with the horizontal side load (defined below) and the horizontal forward load (defined below), both applied at the boom head sheave pin, plus dead load and wind load (defined below), without exceeding the AISC allowable unit stresses. The horizontal loads and wind loads corresponding to the Category 2 Design Load ($DL_2$) are:

a. When the purchaser supplies the specific Significant Wave Height(s) ($H_{sig}$) the offlead and sidelead forces shall be a function of $H_{sig}$ as:

The horizontal forward load at the boom tip ($W_{off}$) shall be:

$$W_{off} = DL_2 \left(2.5 + 1.5 H_{sig}\right) / \left[H_w + B_1 \sin \phi\right] \text{ Newtons}$$

$$W_{off} = DL_2 \left(2.5 + 0.457 H_{sig}\right) / \left[0.305 \left(H_w + B_1 \sin \phi\right)\right] \text{ Pounds}$$

The horizontal side load at the boom tip ($W_{sid}$) shall be:

$$W_{sid} = W_{off} / 2; \text{ but not less than } 0.02 DL_2$$

$B_1$ = Boom Length

$\phi$ = Boom angle to horizontal

$H_w$ = Distance from boom heel pin to the supply boat deck

b. When the purchaser supplies specific offlead and sidelead angles, the offlead ($W_{off}$) and sidelead ($W_{sid}$) forces shall be a function of the specified angles as:

$$W_{off} = DL_2 \left[100 \left[\text{TAN} \left(\text{offlead angle}\right)\right]\right]$$

$$W_{sid} = DL_2 \left[2 + 100 \left[\text{TAN} \left(\text{sidelead angle}\right)\right]\right]$$

c. Wind load shall be computed using conventional pressure versus velocity formulas with appropriate shape coefficients for the particular portion of the crane in question, as found in the literature\(^1\). Wind velocity shall be supplied by purchaser. Crane components whose load rating shall be checked for effect by wind are the boom, gantry, swing mechanism (drive torque, and gear tooth loads), swing-circle assembly, foundation bolts (or fastenings), and pedestal. Wind loads on the boom shall be applied as follows:

1. Wind loads acting on the faces of the lifted load shall be added to the horizontal side load and forward load at the boom head as an added percentage of the vertical design load. Each horizontal load (side and forward) shall be based on a minimum frontal area (exposed to wind) assumed to be one face of a cube whose volume is based on an assumed average specific weight of 200 lb/ft\(^3\) (31.4 kN/m\(^3\)) and whose

\(^1\) For an example, see API RP 2A-WSD: Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms—Working Stress Design, December 2000, paragraph 2.3.2 and its subparagraphs.
total weight equals the vertical design load. Hence, the area of this face in square feet ($m^2$) can be defined as:

$$\frac{\text{Vertical Design Load (lbs)}}{200}^{2/3}$$

$$\frac{(\text{Vertical Design Load (kN)}}{31.4}^{2/3}$$

Actual computed wind area may be used in lieu of the above.

2. Wind loads on the boom, normal to the plane of the boom, can be converted to an equivalent horizontal side load (at the boom tip) which produces the same horizontal moment at the boom foot pin(s), if the design engineer so desires.

3. Wind loads acting on the boom, parallel to the plane of the boom shall be converted into an equivalent distributed line load acting normal to the boom and adding to dead load bending. The component of wind load co-axial with the boom centerline may be neglected during boom analysis.

5.1.3 Exceptions to Use of the AISC Specification

Swing bearings, their bolt connections and foundation bolts in general, are not to be analyzed in accordance with the AISC Specification. The specific design requirements of swing bearings and bolting are presented in Section 9 of this Specification 2C.

5.1.4 Fatigue

In the absence of data on projected frequency and magnitude of lifted loads during the expected life of the crane, every critical structural component of the crane shall be designed to withstand a minimum of 25,000 cycles of its controlling design load and associated horizontal loads (as defined in paragraph 5.1.2 of this Specification 2C and its subparagraphs) in accordance with the allowable fatigue stresses as given in Appendix B of the AISC Specification.

Furthermore, the design engineer shall give due regard to hot spot stresses in the base metal adjacent to the toe of welds, especially those welds which constitute the main load path in transferring load and which rely on weld length rather than cross section, i.e., a "bottleneck" in flow of stress. This hot spot stress can be defined as that which would be measured by a strain gauge element adjacent to the toe of the weld after stable stress cycles are achieved (or shakedown) during prototype testing. Finite element analysis compatible with this definition may be used to calculate this stress, as well as appropriate empirical equations based on such analyses or test results. Fatigue curve $X$ found in the section entitled "Fatigue" of API RP 2A shall be used to obtain an allowable stress compatible with this definition.

If the purchaser supplies information on expected frequency and magnitude of lifted loads, the design engineer may use either Appendix B of the AISC Specification or the fatigue curves in Section 10 of AWS D1.1-2000 as follows:

a. To size structural components to meet fatigue requirements during the design step, or

b. To perform a fatigue analysis to estimate the expected fatigue life of an existing design

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1 AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings, latest edition

2 See definition of critical in Section 3 and see Appendix A: Example List of Critical Components

3 API RP 2A-WSD: Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms—Working Stress Design, December 2000, Section 5, Figure 5.4-1—Fatigue S-N Curves.

4 AWS D1.1—2000: Structural Welding Code—Steel
5.2 CERTIFICATION

The purchaser shall have confidential access to manufacturer's design calculations, associated drawings and other such pertinent information necessary to assure compliance with this Specification 2C. The manufacturer shall certify that the crane furnished to this Specification 2C meets the material and dimensional specifications used in the calculations.

Section 6—Design Authentication and Testing

6.1 DESIGN AUTHENTICATION

Testing shall be used to verify the design method\(^1\). The intent is to verify the overall design calculation procedure's accuracy and completeness. This shall be accomplished either by performing a strain gauged load test to 1.33 times static rated load or by performing a "heavy lift" test to 2.0 times static rated load. The results of the test shall prove the design adequacy either, by review of measured stresses in the gauged test, or by absence of measurable deformation, cracking, or damage in the heavy lift test. The manufacturer shall certify that a prototype, design, or major structural revision to a design has been tested in accordance with either paragraph 6.1.1 or 6.1.2 as set out below.

6.1.1 Resistance Type Strain Gauge Test

This test shall be performed with the crane subjected to 1.33 times the static rated load and a corresponding increase in side loading effects. Strain gauges shall be placed in locations to verify that the uniform stress levels in the crane major components are as established in the design calculations. Strain gauges shall also be placed in areas of peak stresses (transitions, connections, etc.) to verify that peak stress levels are acceptable\(^2\). Deflection of the boom due to sideload shall be measured and limited to 24 inches per 100 feet of boom length. Test loads and boom lengths shall be selected to produce maximum stress levels in all critical\(^3\) structural components.

6.1.1.1 Care shall be taken to obtain the zero reference reading for the strain gauges with near zero stress levels in the components. This is particularly critical in long boom lengths and other components where dead weight loading is significant. For long boom lengths, multiple support points shall be provided to minimize boom dead weight effects while zeroing the strain gauges. The crane should be exercised by lifting loads prior to strain gauging to allow break-in of the components.

6.1.1.2 Stresses in different parts of the crane structure shall be measured and evaluated to the following criteria:

a. Uniform stress regions are areas of near-uniform stress where exceeding the yield strength will produce permanent deformation of the member as a whole. In uniform stress regions, a minimum strength margin of 1.5 is required, where a strength margin is computed as the minimum specified member yield strength divided by the measured gauge stress.

b. Peak stress regions are small areas of high stress surrounded by larger

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\(^1\) For more information, see Appendix B—Commentary, paragraph B.6.1, Design Authentication
\(^2\) For more information, see Appendix B—Commentary, paragraph B.6.1.1, Resistance Type Strain Gauge Test
\(^3\) See definition of critical in Section 3 and see Appendix A: Example List of Critical Components
areas of considerably lower stress where exceeding the yield strength will not produce permanent deformation of the member as a whole. The strain gauges in the peak stress location should have a minimum strength margin (minimum specified yield strength divided by measured gauge stress) of 1.1.

c. Groups of gauges shall be placed in uniform stress regions of main members such that their stresses may be combined to determine the member primary axial and bending stress. These shall then be compared to design calculations to verify member stress levels are as predicted. Groups of gauges shall typically be placed to verify boom primary axial and bending stress, gantry leg axial stress, and in any other region where primary axial and bending stress calculations were made during design.

6.1.2 Heavy Lift Load Test

This test shall consist of lifting 2.0 times the static rated load with a corresponding sideload equal to 4% of the static rated load. Test loads and boom lengths shall be selected to produce maximum stress levels in all critical structural components. Following the lifts, the crane shall be completely disassembled, including the swing-circle assembly, and subjected to a complete fitness-for-purpose evaluation using an appropriate method of inspection (depending upon the component) chosen from the following:

1. Dye penetrant
2. Magnetic particle
3. Radiographic
4. Ultrasonic

The acceptability criteria for this test shall be that no critical components exhibit any yielding, buckling, indentations, or surface cracks. Special attention shall be given to bolted and welded connections. Measurements and inspections shall be made before and after the test to determine any differences in condition of critical components. An accompanying requirement of the test shall be that computed stresses under the test loads specified above shall not exceed the AISC Specification allowable unit stresses increased by one-third.

6.2 CERTIFICATION

The purchaser shall have confidential access to the manufacturer's documentation of the results of the selected method of testing. The manufacturer shall certify that the design of the crane furnished has been authenticated in accordance with this Specification 2C.

6.3 OPERATIONAL TESTS

In addition to the prototype test and quality control measures established by this Specification 2C, each new production crane, at the option of the buyer, shall be tested by the manufacturer at his fabrication facility. The purchaser, or his designated representative, may witness the test. This test procedure, as agreed upon between buyer and manufacturer, is intended to verify safety systems as well as operational systems at rated capacity and full speed. Testing may include, but is not limited to, the following:

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1 See definition of fitness-for-purpose in Section 3
1. Auxiliary and main line load tests at various radii.
2. Speed tests for main line, boom luff and swing.
3. Swing and free swing tests.
4. Overload test (1.33 times rated capacity), or as otherwise specified by buyer.
5. Anti two-block tests.
6. Upper and lower boom kick-out tests.
7. Engine functional tests.

Section 7—Critical Rigging Components

7.1 GENERAL
Suspension and hoist systems are comprised of certain rigging equipment. Components of rigging equipment that meet the critical\(^1\) component definition shall be considered critical rigging components and shall comply with the requirements of this section.

7.2 WIRE ROPE
All wire rope used in hoist and suspension systems shall comply with the requirements set out below.

7.2.1 Construction
Wire rope shall be of a construction specified by the crane manufacturer for each wire rope service. The requirements of the latest edition of API Specification 9A\(^2\) shall be the minimum specification for wire rope used on offshore cranes. Rotation-resistant ropes and fiber core ropes shall not be used for boom hoist reeving.

7.2.2 Inspection, Maintenance and Replacement (IMR)
The crane manufacturer shall provide IMR\(^3\) procedures for all wire rope used in the crane. The procedures shall comply with the minimum criteria given in API RP 2D\(^4\).

7.2.3 Wire Rope Load
Wire rope load is defined as the maximum system force generated in the load hoists, boom hoist and suspension systems by the effects of rated load, dead weight, offlead, wind and lifting geometry.

7.2.4 Design Factors
Wire rope design factors shall be determined by multiplying the single wire rope nominal breaking load by the number of supporting ropes and dividing by the wire rope load. Wire rope design\(^5\) factors are intended to account for end connector efficiency and total reeving system efficiency of 80% or greater.

7.2.4.1 Hoist Systems — The design factor of wire rope reeving used in load hoist and

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\(^1\) See definition of critical and see Appendix A: Example List of Critical Components
\(^2\) API Specification 9A: API Specification for Wire Rope
\(^3\) Additional information regarding IMR criteria for rotation-resistant rope are presented in Appendix B—Commentary, paragraph B.7.2.2 of this Specification 2C.
\(^4\) API RP 2D: Recommended Practice for Operation and Maintenance of Offshore Cranes, latest edition
\(^5\) Refer to Appendix B—Commentary, paragraph B.7.2.4 for other assumptions underlying wire rope design factors.
boom hoist systems shall not be less than 2.5 times $C_b$ (or $C_f$) or 5.0, whichever is greater.

7.2.4.2 Suspension Systems — The design factor of standing wire rope used for boom pendants and other support systems shall not be less than 2.0 times $C_b$ (or $C_f$) or 4.0, whichever is greater.

7.2.4.3 Personnel Hoist System — The design factor of load hoist wire rope when handling personnel shall not be less than 10.0.

7.3 WIRE ROPE END TERMINATIONS

7.3.1 U-Bolt and Fist Grip Clips
Extreme care should be exercised to assure proper orientation of U-bolt clips. The U-bolt segment shall be in contact with the wire rope dead-end. The orientation, spacing, torquing, and number of all clips shall be in accordance with the crane manufacturer's specifications.

7.3.2 Eye Splice
Eye splices shall have a minimum of three full tucks. Other details of eye splicing shall be specified by the crane manufacturer.

7.3.3 Wedge Sockets
Wedge sockets shall be installed with the live-load-side of the wire rope in line with the wedge socket pin. Wire rope clips used in conjunction with wedge sockets shall be attached to the unloaded (dead) end of the rope as shown in Figure 4. Wedge socket assemblies shall withstand wire rope failure without permanent yield to wedge socket.

7.3.4 Termination Efficiency
Wire rope end terminations shall not reduce wire rope strength below 80% of the wire rope nominal breaking load.

7.3.5 Installation Procedure
Detailed installation procedures for wire rope end termination shall be specified by the crane manufacturer.

7.4 SHEAVES

7.4.1 Requirements
All sheaves\(^1\) that are a part of any crane hoist system shall comply with this Specification 2C.

7.4.1.1 Sheave pitch diameter (D) to nominal wire rope diameter (d) ratio (D/d) shall not be less than 18, (see Figure 3).

7.4.1.2 Sheave groove contour shall be smooth and free from defects injurious to the wire rope. Groove surface finish shall be as indicated on the crane manufacturer's drawing.

7.4.1.3 Sheave groove angle shall taper outward and shall not be less than a 30 degree included angle. Groove flange corners shall be rounded. The rim concentricity and perpendicularity about the rotation axis shall be within tolerances stated on the crane manufacturer's drawing.

7.4.1.4 Sheave groove radius for wire rope support shall be sized for the specified

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\(^1\) For more information, see Appendix B—Commentary, paragraph B.7.4.1.
wire rope diameter in accordance with Table 1.

7.4.1.5 Sheave bearings shall be individually lubricated through a separate passage. Permanently lubricated bearings are exempt from this requirement.

7.4.1.6 Sheave guards — All sheaves including running blocks shall be provided with guards or other suitable devices to prevent the rope from coming out of the sheave groove.

7.5 LOAD BLOCK ASSEMBLIES

7.5.1 Hook Block

The hook block is the main hoist system load block used in main boom lifting operations.

7.5.1.1 Sheave bearings shall be sized to be suitable for the intended service.

7.5.1.2 The weight of the hook block shall be sufficient for the boom length and parts of line specified to prevent slack wire rope when the main hoist drum is unwinding at maximum speed.

7.5.1.3 Cast iron material shall not be used to provide additional hook block weight.

7.5.2 Overhaul Ball Assembly

The overhaul ball assembly is the single part auxiliary hoist system hook and weight assembly used in tip extension lifting.

7.5.2.1 The weight of the overhaul ball assembly shall be sufficient for the boom length to prevent slack wire rope when the auxiliary hoist drum is unwinding at maximum speed.

7.5.2.2 Cast iron material is acceptable for use in the ball weight.

7.5.3 Load Block

7.5.3.1 The loads on this component are the maximum static, dynamic and personnel handling rated loads.

7.5.3.2 As a minimum, the rating label(s) shall contain the load block maximum static and personnel rated loads, service temperature and assembly weight. The label shall be permanently affixed to the hook block and overhaul ball. The maximum dynamic rated load(s) may be added at the option of the purchaser.

7.5.4 Load Hook

The load hook is a fitting incorporated in the hook block and overhaul ball to facilitate connection of the load to the hoist system.

7.5.4.1 The hook material shall be alloy steel and produced as a forging or casting.

7.5.4.2 The fracture toughness of each heat of steel employed in the production of hooks shall be verified by Charpy impact testing. The tests shall be conducted in accordance with ASTM Specification E 23\(^1\) to yield a minimum of 25 ft-lbs average on a set of three Charpy test bars. No single value shall be less than 15 ft-lbs at minus forty degrees (-40\(^\circ\)Fahrenheit [34 Joules average/20 Joules minimum at minus forty degrees (-40 \(^\circ\)) Celsius.

7.5.4.3 Hooks shall be equipped with a latch to retain loose lifting gear under non-

lifting conditions. The latch shall be lockable if the hook is to be used for transporting personnel. The latch is not intended to support the lifted load.

7.5.5 Load Block Design Factors

Design factors shall be determined by dividing the load block minimum plastic failure load by the corresponding load block loads.

7.5.5.1 The static rating design factor shall not be less than 4.0.
7.5.5.2 The dynamic rating design factor shall not be less than 3.0 times \( C_p \) or \( C_f \).
7.5.5.3 The personnel rating design factor shall not be less than 12.0.

7.5.6 Design Verification

A prototype design shall be tested to establish the validity of underlying design concepts, assumptions and analytical methods.

7.5.6.1 A proof load of 2.0 times the static rating shall be applied without permanent deformation.
7.5.6.2 A plastic failure load shall be confirmed by destructive testing. Differences between actual and minimum material properties shall be taken into account.

Section 8—Boom Hoist, Load Hoist, and Telescoping Boom Mechanisms

8.1 HOISTS

Boom and load hoists shall be approved by the hoist manufacturer for personnel handling and shall be so indicated on their nameplate\(^1\). Hoists shall also conform to standards of performance and serviceability as set out below.

8.1.1 Brakes

8.1.1.1 Brakes and clutches shall be provided with adjustments, where necessary, to compensate for wear and to maintain adequate force on springs where used.

8.1.1.2 When power operated brakes having no continuous mechanical linkage between the actuating and braking means are used for controlling loads, an automatic means shall be provided to set the brake to prevent the load from falling in the event of loss of brake actuating power.

8.1.1.3 Brakes shall be provided to prevent the drum from rotating in the lowering direction and shall be capable of holding the rated load indefinitely without attention from the operator. Brakes shall be automatically applied upon return of the control lever to its center (neutral) position. Brakes, which are applied on stopped hoist drums, shall have sufficient impact capacity to hold 1.5 times the rated torque of the hoist.

8.1.1.4 Boom or load lowering shall be done only by engagement to the power train. Free fall lowering of the boom, or load, shall not be permitted.

8.1.1.5 Hoists designed to control descent of a load or boom exclusively through

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\(^1\) Refer to paragraph 17.1 of this Specification 2C for required manufacturer nameplate information.
modulation of a friction device shall be able to operate continuously for one hour, raising and lowering the rated load at maximum design speed over a height of 50 feet (15 meters). Dwell time between raising and lowering operations shall not exceed three seconds. Coolant flow shall be maintained within limits specified by the hoist manufacturer. At the end of this test, the brake shall have adequate capacity to smoothly stop 110% of the rated load from the maximum design speed in the lowering mode while lowering.

8.1.1.6 Hoists designed to control descent of a load or boom by controlling the speed of the hoist drive input shall be capable of smoothly stopping 110% of rated load from maximum speed while lowering without exceeding the manufacturer’s specified temperature limits for any drive train component.

8.1.1.7 Except as noted below, hoists shall be provided with a dynamic friction braking system that shall actuate automatically to bring the hoist to a smooth stop in the event of a control or motive power loss.

8.1.1.8 Hoists designed to control the descent of a load or boom by controlling flow from a fluid cylinder, or from a fluid drive motor attached directly to the hoist, shall not require dynamic friction braking provided:

1. The control device is connected directly to the lowering outlet port without the use of hoses.
2. The control device requires positive pressure from the power source to release and actuates automatically to bring the hoist or cylinder to a smooth stop in the event of a control or motive power loss.
3. The braking system is effective throughout the operating temperature range of the working fluid.

8.1.2 Drums

8.1.2.1 All drum(s) shall provide a first layer rope pitch diameter of not less than 18 times the nominal rope diameter (See Figure 5). The flange shall extend a minimum of 1/2 inch (13 mm) over the top layer of rope at all times.

8.1.2.2 Drum(s) shall have sufficient rope capacity with recommended rope size(s) to operate within the range of boom lengths, operating radii and vertical lifts as agreed to between the manufacturer and the purchaser.

8.1.2.3 No less than five (5) full wraps of rope shall remain on the drum(s) in any operating condition. The drum end of the rope shall be anchored to the drum by an arrangement provided by the crane manufacturer.

8.1.3 Components

Components shall be designed to minimize the likelihood of incorrect use or assembly as set out below.

8.1.3.1 A single part, meeting all applications, shall be used. Interchangeable parts, which differ only in material, shall not be used.

8.1.3.2 All critical drive components shall have unique spline, keying, or other arrangements to prevent improper installation or interchange of parts.

8.1.3.3 Where the above provisions cannot be met, parts in question shall be clearly marked and specific warnings on interchangeability included in the operating and
maintenance manuals.

### 8.1.4 Mounting

The crane manufacturer shall be responsible for the design and testing of hoist foundations, and mounting of hoists as set out below.

8.1.4.1 Alignment of hoist components shall be maintained within limits that prevent premature deterioration of gear teeth, bearings, splines, bushings, and any other parts of the hoist mechanism. Where alignment may be disturbed by disassembly, means for field alignment shall be provided.

8.1.4.2 The hoist manufacturer shall provide a mounting procedure that prevents excessive distortion of the hoist base as it is attached to the mounting surface. Flatness of the mounting surface shall be held to tolerances specified by the hoist manufacturer.

8.1.4.3 Distortion of the mounted hoist assembly under load shall not exceed limits specified by the hoist manufacturer. The hoist manufacturer shall establish a procedure for prototype testing and monitoring of distortion under test load. This testing shall be conducted for the maximum rated line pull throughout the recommended range of wire rope departure angles for the hoist.

8.1.4.4 Attachment of the hoist to the structure shall be sized to resist at least 2.0 times the reactions induced at maximum attainable line pull.

### 8.1.5 Lubrication and Cooling

Lubrication and cooling criteria are set out below.

8.1.5.1 All hoists shall be equipped with means to check lubricant and coolant levels. The means shall be readily accessible with wire rope in place and shall not require the use of special tools. Maximum and minimum levels shall be clearly indicated.

8.1.5.2 Hoists, which use a circulating fluid for lubrication or cooling, shall be provided with means to check the fluid level while in operation\(^1\).

8.1.5.3 Hoists, which use a closed lubrication system, shall have a fluid capacity of at least 120% of the manufacturer's minimum recommended operating level.

### 8.1.6 Comparative Power Ratings

The manufacturer shall supply to the purchaser a Comparative Power Rating\(^2\) (CPR) for each hoist unit on the crane. The published CPR shall be the lesser of CPR\(_s\), CPR\(_d\), or CPR\(_b\), as set out below.

8.1.6.1 Gearing — The CPR for spur, helical, and herring bone gears shall be determined using the formulas below based on the following American Gear Manufacturer’s Association (AGMA) Standards: ANSI/AGMA 2001-C95\(^3\), AGMA 908-B89\(^4\), and ANSI/AGMA 6010-F97\(^5\).

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\(^1\) Refer to paragraph 13.4 of this Specification 2C and its subparagraphs for requirements.

\(^2\) For more information, refer to Appendix B—Commentary, paragraph B.8.1.6.

\(^3\) ANSI/AGMA 2001-C95: *Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth*

\(^4\) AGMA 908-B89 (R1999): *Information Sheet – Geometry Factors for Determining the Pitting Resistance and Bending Strength of Spur, Helical and Herringbone Gear Teeth*

\(^5\) ANSI/AGMA 6010-F97: *Standard for Spur, Helical, Herringbone, and Bevel Enclosed Drives*
Where:

\( N_p \) = Pinion speed, at bare down single line pull and single line speed, RPM  
\( d \) = Pitch Diameter of pinion, inches (mm)  
\( K_v \) = Dynamic factor, strength  
\( C_v \) = Dynamic factor, durability  
\( F \) = Net face width of narrowest of the mating gears-inches (mm)  
\( K_m \) = Load distribution factor, strength  
\( K_{sf} \) = Strength service factor  
\( C_m \) = Load distribution factor, durability  
\( C_{sf} \) = Durability service factor  
\( C_p \) = Elastic coefficient  
\( C_h \) = Hardness factor, durability  
\( J \) = Geometry factor, strength  
\( I \) = Geometry factor, durability  
\( P_d \) = Diametrical pitch, in. (mm)  
\( S_{at} \) = Allowable bending stress for material, PSI (MPa)  
\( S_{ac} \) = Allowable contact stress number, durability

The values of \( K_v \), \( C_v \), \( K_m \), \( C_m \), \( C_p \), \( J \), \( I \), \( S_{at} \), and \( S_{ac} \) can be determined using the tables and curves from the appropriate AGMA Specification. For this determination: \( K_{sf} = 0.90 \) and \( C_{sf} = 50 \). The remaining values will be the physical or operating characteristics pertaining to the gears.

8.1.6.2 Bearings — The CPR for bearings shall be determined by the following formula:

\[
CPR_b = \frac{S \cdot LP_{5000}}{33,000} \text{ (horsepower)} \quad \text{or} \quad CPR_b = \frac{S \cdot LP_{5000}}{32,630} \text{ (kilowatts)}
\]

Where:

\( S \) = maximum rated line speed, at rated single line pull—feet/minute (meters/minute)  
\( LP_{5000} \) = Line pull to yield a 5,000 hour B-10 bearing life—lb. (N)

Note: \( S \) and \( LP_{5000} \) shall be for the same layer of rope on the drum.

8.1.7 Flexible Splines and Other Coupling Arrangement Ratings

Flexible splines and other coupling arrangements shall have a design life that is greater than the gear train and/or bearings at rated load and maximum rated speed when operating within the alignment limits of paragraph 8.1.4 above and its sub-paragraphs.

8.1.8 Performance

Boom and load wire rope hoist line pulls that are used for static, dynamic, and personnel rated loads shall account for reeving system friction losses based on the following formulas:

\[ L = PNE \]
\[
E = \frac{(K^N - 1)}{K^S N (K - 1)}
\]

Where:

- \( L \) = Rated load
- \( P \) = Available hoist line pull with load at boom head
- \( N \) = Number of line parts supporting load
- \( E \) = Reeving system efficiency
- \( K \) = Bearing constant: 1.045 for bronze bushings; 1.02 for roller bearings
- \( S \) = Total number of sheaves in traveling block and top block or boom point

### 8.2 BOOM CONTROL

#### 8.2.1 Hoist Mechanism (Rope Drive)

The boom hoist mechanism is the device used to control the elevation of the boom and support the boom. The boom hoist mechanism shall be capable of the following:

- 8.2.1.1 Elevating the boom from a minimum boom angle of 10 degrees below horizontal to the maximum recommended boom angle.
- 8.2.1.2 Elevating and controlling the boom and design load within recommended minimum and maximum boom angles.
- 8.2.1.3 Supporting the boom and 110% of design load within the recommended minimum and maximum boom angles.

#### 8.2.2 Boom Control Cylinder

A hydraulic cylinder or cylinders may be utilized to control the elevation of the boom and support the boom as set out below.

- 8.2.2.1 The cylinder(s) mechanism shall be capable of elevating the boom from a minimum of zero degrees to the maximum recommended boom angle.
- 8.2.2.2 The boom cylinder(s) shall be capable of elevating and controlling the design load within recommended minimum and maximum boom angles.
- 8.2.2.3 The boom cylinder(s) shall be capable of supporting the boom and 110% of design load within recommended minimum and maximum boom angles.

#### 8.2.3 Auxiliary Holding Device

A holding mechanism shall be provided for boom support regardless of the type of drive.

- 8.2.3.1 On rope boom support machines, a ratchet and pawl, or other positive holding device, shall be provided to prevent unintentional lowering of the boom.
- 8.2.3.2 For hydraulic cylinder boom support machines, a holding device (such as integrally mounted check valves) shall be provided to prevent uncontrolled lowering of the boom.

### 8.3 TELESCOPING BOOM MECHANISMS

A telescoping boom consists of a base boom from which one or more boom sections are telescoped for additional length (See Figure 1, Types A and B). Extension and retraction may be accomplished through hydraulic, mechanical, or other means.
8.3.1 Power Retract Function

The power retract function shall be capable of controlling design load and capable of supporting 110% of the design load within the recommended minimum and maximum boom angles.

8.3.2 Power Extend Function

The powered extend function is not required to extend under load unless otherwise specified by purchaser.

8.3.3 Holding Device

A holding device (such as check valves) shall be provided with telescoping cylinder(s) to prevent uncontrolled movement of the cylinder(s). Hoses shall not be used between the cylinder(s) and the holding device(s).

Section 9—Swing Mechanism

9.1 SWING MECHANISM

The swing mechanism is the means to rotate the upper-structure of the machine. The swing mechanism shall be capable of smooth starts and stops with controllable rates of acceleration and deceleration as set out below:

9.1.1 Parking Brake

A brake with holding power in both directions, to restrain movement of the upper-structure but not to retard the rotation motion of the upper-structure during operation, shall be provided. This brake shall be controllable by the operator at the operator’s station. The brake shall be capable of remaining in the engaged position without the attention of the operator.

9.1.2 Automatic Parking Brake

If the swing mechanism brake is of the automatic type, return of the swing control lever to neutral shall not engage the brake in a manner that abruptly arrests the swing motion. An automatic swing brake, that is incapable of controlled deceleration, shall not be used.

9.1.3 Dynamic Friction Brake

A dynamic friction brake to stop, hold, or retard the rotation motion of the upper-structure may be provided. When provided, it shall be controllable by the operator at the operator’s station. It may also satisfy the requirements of paragraph 9.1.1 above.

9.1.4 Design Swing Moment

The swing mechanism shall be designed with sufficient strength and capacity to rotate the upper-structure for all rated load, radii, and boom lengths. In the absence of information from the purchaser, the swing mechanism shall be designed to rotate the upper-structure and rated load with a 1/2 degree tilt and a 30 mile per hour (48 kilometer per hour) wind applied to the upper-structure, boom, and an equivalent rated load area as described in paragraph 5.1.2.2.c.1 of this Specification 2C. The tilt and the wind shall be applied concurrently in such a manner to maximize the required design swing moment (both opposing the rotation direction). Wind loading shall be calculated in the same manner as described in paragraph 5.1.2.2.c.

9.2 SWING LOCK
A mechanical device (not dependent on friction) for positively locking the upper-structure in one or more fixed positions may be provided. When provided, it shall be constructed to withstand the maximum swing torque developed by the swing mechanism, prevent accidental engagement or disengagement, and shall be controllable by the operator at the operator’s station.

9.3 SWING-CIRCLE ASSEMBLY

The swing-circle assembly is the connecting component between the crane revolving upper-structure and the pedestal. This component allows crane rotation and sustains the moment, radial, and axial loads imposed by crane operation. The swing-circle assembly may be a roller bearing, ball bearing, or hook roller design as shown in Figures 6 and 7, or a king post design as shown in Figure 1. The swing-circle assembly shall conform to the specifications set out below.

9.3.1 Design

The factors used in determining the adequacy of the swing-circle assembly shall include:

9.3.1.1 Design Service Factor — The combination of the following basic static loads shall be calculated using the maximum of the Category 1 or 2 Design Load condition plus dead load.

1. Overturning Moment
2. Axial
3. Radial

These loads may occur simultaneously and result in the maximum stress in the swing-circle assembly. Modification of ratings for dynamic effects are covered in paragraph 4.1.2 of this Specification 2C and will not increase swing-circle assembly design loads.

9.3.1.2 Swing-Circle Life — Members subjected to repeated stress cycles shall be designed for adequate resistance to structural fatigue degradation. The calculated fatigue life of the assembly shall be substantially in excess of the rolling contact wear (B 10) life as defined by ABMA Standard 9 for ball bearings; ANSI/ABMA Standard 11 for roller bearings; or ISO 281, as applicable.

9.3.1.3 Working Environment — Anti-friction bearings shall be sealed from foreign and marine environmental contamination.

9.3.1.4 Ultimate Strength Design Criteria — The design criteria of the swing-circle assembly, including fasteners shall be as follows: The maximum calculated stress is equal or less than the minimum specified ultimate tensile strength of the material with the dead load plus 3.75 times the maximum of the Category 1 or 2 design load conditions. It shall include the effects of wind, sidelead, and offlead associated with these loads.

The load, due to external loading on the most heavily loaded swing bearer fastener shall be calculated by:

\[ P = \frac{4M}{ND} - \frac{H}{N} \]

Where:

1. American BMA Standard 9: Load Ratings and Fatigue Life for Ball Bearings
2. ABMA Standard 11: Load Ratings and Fatigue Life for Roller Bearings
3. ISO 281: Roller Bearings—Dynamic Load Ratings and Rating Life
4. An exception is the king post design which is treated as a connective element in paragraph 5.1 of this Specification 2C.
$M =$ Moment calculated with dead load + 3.75 times Category 1 Design Load—lb-ft (N-m)

$H =$ Dead Axial Load + 3.75 times Category 1 Design Load—lbs (N)

$D =$ Pitch Circle Diameter of Fasteners—ft (m)

$N =$ Number of Fasteners

### 9.3.2 Material Properties

The steels employed in the manufacture of the swing-circle assembly shall be selected, tested, and verified as adequate to support the design loads of the crane.

#### 9.3.2.1 Bearing Steels

Steels for rolling elements shall be produced to the minimum requirements of ASTM Specification A 295\(^1\). Steels for bearing rings shall be selected to produce the desired properties in the finished ring. Cleanliness of bearing ring steels shall conform to the requirements of Method A of ASTM Specification E 45\(^2\) to the following limits:

<table>
<thead>
<tr>
<th>Inclusion Category</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thin Series</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Thick Series</td>
<td>1.5</td>
<td>1.5</td>
<td>2.0</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Alternate materials of satisfactory properties shall be employed in the design of king post and hook roller assemblies.

#### 9.3.2.2 Heat Treatment of Bearing Raceways

The manufacturer of the swing-circle assembly shall verify the adequacy of the mechanical properties of the case and core of the raceways by performing destructive testing on the material (taken from representative configurations) for each prototype swing-circle design. A report of the material tests shall be compiled indicating the measured values and comparison with the required design analysis. It shall be the responsibility of the crane manufacturer to review the bearing manufacturer’s design assumption and material test data to assure each bearing to be employed on a crane complies with these requirements.

#### 9.3.2.3 Fracture Toughness of Bearing Raceways

The fracture toughness of each heat of steel to be employed in the production of raceways for swing bearings, which are employed as the sole means of restraining separation of the pedestal and the crane, shall be verified by Charpy impact testing. The Charpy tests shall be conducted in accordance with ASTM Specification E 23\(^3\). The tests shall yield a minimum of 31 ft-lbs average on a set of three Charpy test bars with no single value less than 20 ft-lb at minus four (-4\(^\circ\)) Fahrenheit [42 Joules average/27 Joules minimum at minus twenty (-20\(^\circ\)) Celsius]. Tests shall be conducted on a sample of the same cross sectional dimensions as the actual ring after heat treatment and shall exhibit the core hardness required of the finished part. Tests shall be conducted on a sample with the same degree of forming reduction and heat treatment as the ring forging. The length of the test bar shall be oriented parallel to the circumference of the ring. The test specimen shall be removed from the sample at a depth as near as possible to the area of the final ring configuration subjected to maximum calculated stress as in paragraph 9.3.1.4 above.

#### 9.3.2.4 Welding

All welding on races for the attachment of the bearings to the

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\(^1\) ASTM A 295: Standard Specification for High-Carbon Anti-Friction Bearing Steel  
\(^2\) ASTM E 45: Standard Method for Determining the Inclusion Content of Steel  
pedestal or upper frame shall be performed in accordance with the bearing manufacturer's recommended procedures and shall exhibit fracture toughness equivalent to the race base metal. All bearings to be attached to the structure by welding shall be provided with a transition piece of weldable steel. The weld between the hardenable steel and the transition piece shall be subjected to stress relief heat treatment at a temperature not to exceed the tempering temperature employed in the heat treatment of the race.

9.3.3 Mounting and Maintenance

9.3.3.1 Surface Flatness and Finish — The flatness and surface finish requirements specified by the swing-circle assembly manufacturer shall be maintained for both the revolving upper-structure/bearing and pedestal/bearing mating surfaces.

9.3.3.2 Pedestal Deflection — The maximum deflection of loaded conditions shall be within the limits specified by the swing-bearing manufacturer.

9.3.3.3 Swing-circle Assembly Clearance — If the swing-circle assembly is a ball or roller bearing, clearances permitted before the bearing must be replaced and an approved method of measuring such clearances shall be specified in the crane manual.

9.3.3.4 Roller Path Deflection — If the swing bearing assembly is a hook roller arrangement, the assembly shall be adjustable to take up clearance. Allowable clearances and method of adjustment shall be specified in the crane manual.

9.3.3.5 Mounting Details — The crane manufacturer shall provide the following information:

1. Swing-circle assembly mounting dimensions.
2. Maximum overturning moment with corresponding axial and radial load at the crane/pedestal interface.
3. Maximum axial load with corresponding overturning moment and radial load at the crane/pedestal interface.

Moments and axial load shall be calculated with the dead load plus 2.0 times the static rated load.

9.3.4 Threaded Fasteners

Threaded fasteners used to connect the swing-circle assembly to the pedestal or upper-structure shall conform to the requirements as set out below.

9.3.4.1 Bolt Spacing — Connecting bolts shall be equally spaced over the 360 degree mounting circumference. One bolt may be omitted for assembly of the swing bearing. The crane manufacturer may use unequal bolt spacing if structural analysis or prototype crane strain gauge instrumented testing is performed to insure the integrity of the bolted connection.

9.3.4.2 Fatigue Life — The fatigue life of threaded connections shall be determined by calculation. Calculations shall be made available to the swing-circle assembly purchaser.

9.3.4.3 Material Properties — The material used in threaded fasteners shall meet requirements of paragraph 14.5 of this Specification 2C.

9.3.4.4 Pre-Stress Levels — Fasteners shall be pre-stressed to a level that will preclude relief of pre-load in the most heavily loaded fastener under any Category 1 Design Load.
9.3.4.4  Fasteners Markings — Only fasteners permanently marked with the fastener manufacturer's identification mark and SAE, ASTM, or ISO grade-identifying markings shall be used.

9.3.4.5  Rotation Restraints — Fasteners, which are not accessible for inspection, shall be positively restrained from rotation by nonpermanent means.

Section 10—Power Plant

10.1  GENERAL
The power plant is the prime mover and its auxiliary systems, including the power take-off means and the starting system.

10.1.1  Gasoline Engines
Gasoline engines prime movers are not permitted.

10.1.2  Pneumatic Prime Movers
Pneumatic prime movers or auxiliary systems, which use flammable gas as the fluid power medium, are not permitted.

10.2  EXHAUST SYSTEMS — INTERNAL COMBUSTION PRIME MOVERS
The following criteria apply to the exhaust systems of internal combustion prime movers:

10.2.1  Spark Arrestor Type Silencer
Engine exhausts shall be equipped with a spark arresting type silencer.

10.2.2  Exhaust Piping
Exhaust gases shall be piped to the outside of the engine enclosure and discharged in a direction away from the operator.

10.2.3  Exhaust Guards
All exhaust systems shall be guarded in areas where contact by personnel in the performance of their normal duties is possible.

10.3  FUEL TANKS
The criteria set out below apply to fuel tanks.

10.3.1  Neck and Filler Caps
Fuel tanks shall be equipped with filler necks and caps designed to prevent fuel contamination from external sources. Removable caps, where fitted, shall be securely tethered to the filler.

10.3.2  Fuel Tank Drains
Drains shall be provided on all fuel tanks. Drains shall be located to drain the tank below the level of the fuel pick-up.

10.4  HAZARDOUS AREA CLASSIFICATIONS
The latest editions of API RP 500\textsuperscript{1} or API RP 505\textsuperscript{2} shall be used to determine a hazardous area classification. The purchaser shall specify to the manufacturer the classification of the area in which the crane is to be installed. The classification shall consider temporary uses of the area as well as permanently installed equipment. Criteria for power plants installed in such a hazardous area shall be in accordance with Recommended Practice as described in RP 500 or RP 505 as it pertains to elimination of ignition sources. Another source of information is the National Electric Code.

### 10.5 ISOLATION OF IGNITION SOURCES AND HEATED SURFACES

Isolation of ignition sources and heated surfaces shall be in accordance with the latest edition of API RP 14C\textsuperscript{3} where applicable.

### 10.6 DIESEL AIR INTAKE SHUT-OFF

Unless otherwise specified by the buyer, diesel engines shall be equipped with a device to shut the engine intake air in the event of diesel engine runaway. Regulations should be reviewed to insure compliance.

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**Section 11—Controls**

### 11.1 GENERAL

Controls shall be in accordance with the criteria set out below.

#### 11.1.1 Location

All controls used during the normal crane operating cycle shall be located within easy reach of the operator while at the operator's station.

#### 11.1.2 Automatic Return

Control levers for boom hoist, load hoist, swing, and boom telescope (when applicable) shall return automatically to their center (neutral) positions on release.

#### 11.1.3 Marking & Diagrams

Control operations and functions shall be clearly marked and easily visible by the operator at operator's control station. This can be either by marking each control or by a control arrangement diagram.

#### 11.1.4 Emergency Stop

Provisions shall be made for emergency stop of the crane operations by the operator at operator’s control station.

#### 11.1.5 Foot-Operated Controls

Foot-operated pedals, where provided, shall be constructed so the operator’s feet will not readily slip off.

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\textsuperscript{1} API RP 500: Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2

\textsuperscript{2} API RP 505: Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1 and Zone 2

\textsuperscript{3} API RP 14C: Recommended Practice for Analysis, Design, Installation and Testing of Basic Surface Safety Systems for Offshore Production Platforms
11.1.6 Control Forces & Movements
When controls and corresponding controlled elements are properly maintained, adjusted, and operated within the manufacturer's recommendations, the forces and movements required to operate the crane within its rated limits shall not exceed the following:

11.1.6.1 Hand Levers—20 pounds (89 N) and 28 inches (350 mm) total travel.
11.1.6.2 Foot Pedals—25 pounds (111 N) and 10 inches (250 mm) total travel.

11.2 POWER PLANT CONTROLS

11.2.1 Power on Board
Controls for normally operating power plants mounted on the crane revolving structure shall be within easy reach of the operator and shall include means to:

1. Start and stop.
2. Control speed of internal combustion engines.
3. Stop prime mover under emergency conditions.
4. Shift selective transmissions.

11.2.2 Remote Power
Controls for operating the power plant shall be conveniently located on the remote power package and shall include the same provisions as paragraph 11.2.1 above.

11.3 ENGINE CLUTCH
All cranes with a direct mechanical drive to any crane function shall be provided with a clutch or other effective means for disengaging power. The clutch control shall be within easy reach of the operator at the operator's station.

11.4 CRANE CONTROLS—BASIC LEVER OPERATING ARRANGEMENTS

11.4.1 Basic Four-Lever Operating Arrangement
This section applies to conventional four-lever operating crane 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 equipment.

11.4.1.1 Basic controls shall be arranged as shown in Figure 8. Controls shown are levers for hand operation.

11.4.1.2 Controls for all other functions, such as auxiliary drums and throttles, shall be positioned to avoid operator confusion and physical interference. Nothing in this Specification 2C precludes the use of additional controls subject to the foregoing requirements.

11.4.1.3 All basic controls shall operate as specified in Figure 8 and the function chart as shown in Table 2.

11.4.2 Basic Two-Lever Operating Arrangement
This section applies to conventional two-lever operating crane controls. It should not be construed to limit the use of, or apply to, combination controls, automatic controls, or any other special operating control equipment.
11.4.2.1 Basic controls shall be arranged as shown in Figures 9 or 10. Controls shown are levers for hand operation.

11.4.2.2 Controls for all other functions, such as auxiliary drums and throttles, shall be positioned to avoid operator confusion and physical interference. Nothing in this Specification precludes the use of additional controls subject to the foregoing requirements.

11.4.2.3 Basic controls shall operate as specified in Figure 9 or 10 and the function charts as shown in Table 3 or 4.

Section 12—Cabs and Enclosures

12.1 GENERAL

Insofar as practical, all cabs and enclosures shall be constructed to protect the upper-structure machinery, brakes, clutches, and the operator's station from the weather. Cranes without cabs or enclosures to protect the operator, upper-structure machinery, brakes, and clutches shall be adequately protected from the corrosive influence of the sea born environment.

12.2 WINDOWS

All windows shall be of safety glass or equivalent. Windows shall be provided in the front and both sides of the operator's cab for visibility forward and to either side. Visibility forward shall include a vertical range adequate to cover the boom point and load at all times. The front window may have a section that can be readily removed or held open if desired. If the section is removable, storage space shall be provided. If the section is of the type held in the open position, it shall be secured to prevent inadvertent closure.

12.3 DOORS

All cab or enclosure doors, whether of sliding or swinging type, shall be adequately restrained from inadvertent opening or closing while the machine is in operation. The door adjacent to the operator, if of the sliding type, shall slide rearward to open and, if the swinging type, shall open outward. A clear passageway shall be provided to the exit door nearest the operator's station.

12.4 CAB ACCESS

Suitable hand holds or steps shall be provided for access to, and exit from, the operator's cab or enclosure. Handholds shall be provided in accordance with ANSI A 1264.11.

12.5 PLATFORMS AND WALKWAYS

Principle walking surfaces shall be an anti-skid type. Outside platforms, if furnished, shall be provided with guardrails in accordance with ANSI A 1264.1. Two intermediate railings shall be provided in locations where toe boards are not required. All walkways and platforms shall have a minimum width of 30 inches (760 mm), unless otherwise specified by the buyer.

12.6 RIGGING ACCESS

Where necessary for rigging or service requirements, a ladder or steps shall be provided for access and shall conform to the requirements of ANSI A 14.32. Where necessary, areas of cab roof or enclosure shall be capable of supporting the weight of a 200-pound (90 kg) person without

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1 ANSI A 1264.1: Safety Requirements for Workplace Floor and Wall Openings, Stairs, and Railing Systems
2 ANSI A 14.3: Safety Requirements for Fixed Ladders
permanent deformation.

12.7 NOISE LEVEL

Unless otherwise specified by the purchaser, sound levels at the operator's station shall not exceed those set out below:

1. 90 dB(A) (Slow Response) measured with the prime mover at low idle and the crane controls in neutral position.
2. 95 dB(A) (Slow Response) measured with the crane operating at full throttle and full rated load of the rotating machinery.

For the purpose of this Specification, sound level tests shall be conducted on a prototype crane in accordance with applicable sections of SAE J919\(^1\) at the manufacturer's test facility.

When specifying noise level requirements, the purchaser shall consider: the type facility, i.e., manned or unmanned structure, expected crane duty cycle, and background noise levels.

Section 13—Miscellaneous Requirements & Equipment

13.1 BOOM EQUIPMENT

The criteria that apply to the boom are set out below.

13.1.1 Boom Angle Limiters and Shut-off Devices

A boom hoist limiter or shut-off shall be provided to automatically stop the boom hoist when the boom reaches a predetermined high angle. A low angle limiter or shut-off may also be provided as optional equipment.

13.1.2 Resistance to Falling Backward

Boom stops shall be provided to resist the boom falling backwards in a high wind or sudden release of the load. Designs for boom stops include:

1. A fixed or telescoping bumper.
2. A shock absorbing bumper.
3. Hydraulic boom elevation cylinder(s).
4. Auxiliary tips shall be restrained from backward overturning.

13.1.3 Marking and Labeling

13.1.3.1 Booms, boom sections and auxiliary tips shall be permanently identified.

13.1.4 Boom Indicators

Indicators shall be provided per the following:

13.1.4.1 A boom angle or load radius indicator, readable from the operator’s station, shall be provided.

13.1.4.2 A boom length indicator, readable from the operator’s station, shall be provided for telescoping booms, unless the load rating is independent of the load radius.

\(^{1}\) SAE Recommended Practice: Sound Measurement—Off-Road Work Machines—Operator—Singular Type
13.1.4.3 A load indicating or load moment device may be provided as optional equipment.

13.2 GUARDS FOR MOVING PARTS
Guards shall be provided per the following requirements:

13.2.1 Components to Guard
Exposed moving parts such as gears, set screws, projecting keys, chains, chain sprockets, and reciprocating or rotating parts, which may constitute a hazard under normal operating conditions, shall be guarded.

13.2.2 Guard Fasteners and Strength
Guards shall be securely fastened and shall be capable of supporting, without permanent deformation, the weight of a 200-pound (90 kg) person unless the guard is located where it is impossible to step on it.

13.2.3 Warning Signs in Lieu of Guards
If a guard is impractical, it is the responsibility of the manufacturer to warn by means of an appropriate sign. This sign should be designed and installed in accordance with SAE J115\(^1\) consistent with physical limitations on size and location.

13.3 CLUTCH AND BRAKE PROTECTION
All friction brakes and clutches shall be provided with rain guards. Pins, shafts, and bolts in clutch and brake linkages shall be corrosion resistant.

13.4 LUBRICATING POINTS AND FLUID-FILLS

13.4.1 General
Lubricating points on all parts shall be accessible without the necessity for removing guards or other parts. Fluid fill points (fuel, coolant, hydraulic fluid, etc.) shall be located in areas that are easily accessible and will not collect fluid spills.

13.4.2 Fluid Level Indicators
Fluid level indicators should follow the guidelines set forth in SAE Recommended Practice J48\(^2\).

13.4.3 Lubrication Charts, Symbols, and Codes
Lubrication charts shall be furnished by the manufacturer. For preferred symbols and color codes for fluid fills, see SAE J223\(^3\).

13.5 HYDRAULIC AND PNEUMATIC LINE PROTECTION
Exposed lines subject to damage shall be protected as far as practical.

13.6 USE OF ENVIRONMENTALLY SENSITIVE MATERIALS
Paint containing lead or chromate shall not be used on the crane or any of its components. Asbestos shall not be used on the crane or any of its components.

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\(^1\) SAE Recommended Practice J115: *Safety Signs for Construction Equipment*
\(^2\) SAE Recommended Practice J48: *Guidelines for Fluid Level Indicators*
\(^3\) SAE Recommended Practice J223: *Symbols and Color Codes for Maintenance Instructions, Container and Filler Identification*
13.7 ANTI TWO-BLOCK
Means shall be provided to protect hoist ropes, structural components and machinery from damage that may occur when two sheave groups (e.g., load block and boom head) come into contact as the hoist cable is drawn in. A control override device or proximity-warning device may be used. Stalling of the hoist drum is acceptable where damage or loss of control would not result.

13.8 EMERGENCY LOAD LOWERING
Unless otherwise specified by the purchaser, at least one hoist drum shall be provided with a means of lowering in the event of power failure or control system failures. Means shall provide controlled lowering and stopping of the drum under all load conditions. The controls shall be arranged in a manner that will prevent inadvertent engagement. An alternate power source independent of the crane may be used. An instruction plate shall be provided at the operator's station.

13.9 MISCELLANEOUS EQUIPMENT

13.9.1 Toolbox
A toolbox may be provided for storing tools and lubricating equipment. If provided, it shall be secured permanently to the crane.

13.9.2 Hydraulic Circuit Pressures
Means shall be provided for checking the manufacturer's specified pressure settings in each hydraulic circuit.

13.9.3 Hazardous Area Classification
Electrical components on the crane or remote power plants used in areas classified hazardous shall comply with the criteria in paragraph 10.4 of this Specification 2C.

13.9.3.1 Components on the boom shall be rated for the most hazardous area that can be accessed by the boom.

13.9.3.2 The purchaser shall specify to the manufacturer the classification of the area in which the crane will be installed.

13.9.3.3 The classification will consider temporary uses of the area as well as permanently installed equipment.

13.9.4 Audible Warning Device
When specified by the purchaser, an audible signal device shall be provided. The control(s) for the device shall be within easy reach of the operator at the operator's station.

13.9.5 Spillage Containment
All machinery areas, which are subject to liquid leakage, shall be provided with a containment system. The containment well shall have a minimum lip height of 2.0 inches (50 mm) and be provided with a means for draining. Government regulations should be reviewed for applicability.

Section 14—Material Requirements for Structural Components

14.1 MATERIALS
Materials used in the manufacture and fabrication of all critical components of the crane shall comply with the manufacturer's design requirement for strength and fracture toughness\(^1\).

### 14.1.1 Metals

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

1. Chemical Composition Limits
2. Heat Treatment Condition
3. Mechanical Property Limits
   a. Yield Strength
   b. Tensile Strength
   c. Elongation
   d. Fracture Toughness and ductility

### 14.1.2 Testing

The design requirement specifications shall detail the methods of testing to verify the specified properties are present in the as-manufactured or as-fabricated condition. To the extent possible, all materials shall be purchased to specifications of recognized standardization organizations such as those listed in paragraph 2.1 of this Specification 2C.

### 14.1.3 Wire Rope

Refer to paragraph 7.2 of this Specification 2C and its subparagraphs, for wire rope requirements.

### 14.2 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\(^2\). The manufacturing procedures shall be in sufficient written detail to permit duplication of the original processing at any time within the record retention period specified in paragraph 1.4 of this Specification 2C. 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\(^3\) 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.

### 14.3 FRACTURE TOUGHNESS

All critical components of the crane shall exhibit Charpy impact energy values assuring the transition from brittle-to-ductile fracture is at least 10\(^0\) F (6\(^0\) C) below the lowest anticipated service temperature. The design service temperature shall be indicated on the nameplate. Other appropriate fracture control plans considering toughness, allowable flaw size, and inspection requirements may be employed if desired\(^4\). If fitness-for-purpose\(^1\) criteria are employed, the details of the analysis shall be

\(^1\) For more information, refer to Appendix B—Commentary, paragraph B.14.1.
\(^2\) For more information, refer to Appendix B—Commentary, paragraph B.14.2.
\(^3\) See Definition of critical component in Section 3 of this Specification 2C
\(^4\) For more information, refer to Appendix B—Commentary, paragraph B.14.3.
documented for examination, upon request, by the purchaser.

14.4 CASTINGS

The criteria for castings are set out below.

14.4.1 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 source of radiation for examination of casting sections less than 2.0 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 5.

14.4.2 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. The manufacturer shall consider 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.

14.4.3 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 1,100°F (593°C).

14.5 FASTENERS

Threaded fasteners subject to static and/or dynamic tensile loading (other than pre-load) employed in joining of critical components of the crane shall meet the requirements of ASTM A 320/A 320 M. The specific grade of material shall be selected to meet strength requirements, fracture toughness, and corrosion resistance of the service environment. Where bolts of higher strengths than permitted by ASTM A 320/A 320M are desired, the materials shall meet the specifications in SAE Recommended Practices J429 and ANSI B18.2.1. Qualification of the higher strength material 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 tests shall be 30 ft-lbs (40.6 Joules) at 0°F (minus 17.8°C) with no single test value less than 22 ft-lbs (29.8 Joules).

14.6 PLATE

Critical structural elements fabricated from plate, which must transfer loads through the thickness or the short transverse dimension of the plate, shall be ultrasonically inspected in accordance with

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1 See Definition of fitness-for-purpose in Section 3 of this Specification 2C
2 For more information, refer to Appendix B—Commentary, paragraph B.14.4.
3 For more information, refer to Appendix B—Commentary, paragraph B.14.5, Fasteners
5 SAE Recommended Practice J429G: Mechanical and Material Requirements for Externally Threaded Fasteners
6 ANSI B18.2.1: Square and Hex Bolts and Screws—Inch Series
Acceptance Standard—Level B in ASTM A 578/A 578M. They shall be tested for resistance to lamellar tearing in accordance with the procedures and requirements of Supplementary Requirement S-4 of API Specification 2H or ASTM A 770/A 770M.

Section 15—Welding of Critically Stressed Components

15.1 STANDARDS

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. Two such standards organizations and standards are: the American Welding Society AWS D1.1-2000 and AWS D14.3-2000; or the American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section IX—Welding and Brazing Qualifications, latest editions.

15.2 WELDING PROCEDURES

A written procedure specification shall be prepared for all welding. Pre-qualified procedures as defined in AWS D1.1 and AWS D14.3 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 specifications shall be qualified by testing a sample weld produced in accordance with a written procedure and tested in accordance with one of the standards listed in paragraph 15.1 above.

15.3 WELDER PERFORMANCE

The performance of welders shall be verified by destructive testing or 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 welders employing short-circuiting (short-arc) gas metal arc welding processing shall be qualified by destructive testing only.

15.4 WELDING PROPERTIES

The strength and fracture toughness of welds and heat-affected zones in critical components shall meet the minimum specified design requirements of the materials being joined. Mechanical testing shall be conducted during procedure qualification to verify the required properties of the weld and heat-affected zones are attained by the controls outlined in the welding procedure specification.
Section 16—Nondestructive Examination\(^1\) of Critical Components

16.1 NONDESTRUCTIVE EXAMINATION PROCEDURES

The manufacturer shall establish written nondestructive examination procedures\(^2\) for the examination of critical\(^3\) 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 manufacturer's personnel and/or any contract nondestructive examination personnel utilized by the manufacturer.

16.2 NONDESTRUCTIVE EXAMINATION PERSONNEL QUALIFICATIONS

All nondestructive examination personnel employed or contracted for by the manufacturer shall be qualified in accordance with ASNT Recommended Practice SNT-TC-1A\(^4\) at Level H proficiency. For ultrasonic examination of tubular members, the manufacturer shall verify the validity of the procedures and competency of personnel in accordance with the latest edition of API RP 2X\(^5\).

16.3 MINIMUM EXTENT OF NONDESTRUCTIVE 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\(^6\) fracture control plan. The extent of nondestructive examination non-critical components is also the responsibility of the manufacturer.

16.4 EXAMPLES OF WORKMANSHIP STANDARDS

The following are examples of components that may be considered critical in some crane designs, some recognized procedures for conducting nondestructive examinations, and acceptance criteria representing workmanship standards. The manufacturer shall be responsible for developing a similar scheme (with appropriate acceptance criteria) from consideration of the specific crane design, criticality of the component, and applicable nondestructive examination methods. Acceptance criteria based on fitness-for-purpose evaluations shall consider applied and residual stresses, material properties, environmental exposure, and the limitations of the selected nondestructive examination method for detection and evaluation of imperfections.

Insert Table 6 Here: Workmanship Standard Examples

(Note to API: The original table has only one change; ASTM E 70 is changed ASTM E 709 which is revised to include both wet and dry magnetic particle testing.)

Section 17—Marking

17.1 NAMEPLATE

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\(^1\) For more information, refer to Appendix B—Commentary, paragraph B.16, Nondestructive Examination of Critical Components

\(^2\) For more information, refer to Appendix B—Commentary, paragraph B.16.1, Nondestructive Examination Procedures

\(^3\) See Definition of critical component in Section 3 of this Specification 2C

\(^4\) American Society of Nondestructive Testing: Recommended Practice SNT-TC-1A

\(^5\) API RP 2X: Recommended Practice for Ultrasonic Examination of Offshore Structural Fabrication and Guidelines for Qualification of Technicians

\(^6\) See Definition of fitness-for-purpose in Section 3 of this Specification 2C
Cranes to be installed on mobile offshore drilling units and fixed offshore platforms where jurisdictional authority requires nameplate confirmation of construction to this Specification shall have a permanent nameplate of stainless steel or other metallic material of equal corrosion resistance in a marine environment. The nameplate shall be affixed to the structure in a conspicuous location protected from damage and disfigurement. It shall conform to the design shown in Figure 11 with the required information imprinted in legible raised or stamped lettering not less than 1/8 inch (4 mm) high.

17.2 API MONOGRAM

Manufacturers who wish to apply the API trade/service mark to the nameplate as a warranty to the purchaser that construction of the crane complies in all details to this Specification 2C, the manufacturer has obtained an application license from API, and has a quality control system which conforms to API Specification Q1 for Quality Programs should contact the American Petroleum Institute office whose address is imprinted on the cover of this Specification. When applied to the nameplate, the API service mark shall be not less than 1/2 inch high and shall appear in the position shown in Figure 11.

Manufacturers interested in obtaining a monogram license should either write the API Standards Director, 1220 L St., N.W., Washington, DC 20005 (telephone 202-682-8375) for an application package or obtain a copy of the Composite List of Manufacturers Licensed for Use of the API Monogram, Order No. 811-00005.

APPENDIX A

No change—use original page.

APPENDIX B

COMMENTARY

Note: The paragraph numbering of Appendix B corresponds to the text of this Specification 2C. For example, paragraph B.4.1 entitled Rated Load corresponds to paragraph 4.1 of the Specification, entitled Rated Load.

B.4.1 Rated Load

The load rating system for pedestal cranes addresses the unique problems of these machines. Being attached to a rigid base, pedestal cranes are more susceptible to operational overloads in on-platform use. In addition, the high-speed capabilities required for off-platform operations increase the impact potential in on-platform lifts. Static rated load, therefore, has been established at 75 percent of the design load. Off-platform operations involve impact factors larger than on-platform operations. Dynamic rated load de-rating coefficients shall be at least as large as the static de-ration.

B.4.1.1 Static Rated Load

The static rated load as defined in this Specification 2C is intended to apply to static lifts with a crane either mounted to a bottom-supported structure or to a floating structure of sufficient size that the structure experiences no significant listing. The Specification 2C Committee contends that static ratings do not apply to floating cranes, floating derricks, nor barge mounted cranes or derricks. For such applications, paragraph 4.1.2 of this Specification 2C should be utilized to obtain ratings that are analogous to static ratings but would technically be classified as dynamic ratings for calm
conditions, and would include sidelead and offlead angles based on expected vessel list.

**B.4.1.2 Dynamic Rated Load**

The treatment of dynamic effects in this Specification 2C represents the Committee's efforts to establish crane de-ratings that minimize the probability of failure in a dynamic environment. The Committee carefully studied the state-of-the-art in structural dynamics analysis and found that very sophisticated theoretical modeling techniques do exist in the literature. However, it is obvious that dynamic load charts produced from the most sophisticated computational methods available would be of no more value to an offshore crane operator than one generated from simplified assumptions since the operator must react to rapidly changing environmental conditions. For this reason and others, the single degree-of-freedom (DOF) mathematical model was adopted. Although the rating method adopted here will make offshore crane lifts safer, it has no provisions for dealing with the extreme dynamic overloads such as accidental connection to a supply vessel or stopping a falling load, etc. Such overloads can be unbounded and cannot be computationally incorporated into a rating chart.

**B.4.2.3 Safety Margins**

To provide a substantially increased structural safety margin for personnel handling, the rated load for these operations is established at one-third (1/3) of the static rated load. This provides a factor of 4.0 against allowable stresses and at least 6.0 against yield for structural components. Increased design factors for wire rope strength are also provided.

**B.4.2 Dynamic Coefficients**

Calculation of dynamic coefficients is based on a single DOF (degree of freedom) mathematical model. Although multiple DOF models have demonstrated enhanced ability to predict stresses in crane components, the single DOF model should adequately predict effects on the crane foundation. While stresses in the boom and other components are important for establishing service life, the primary safety concern lies in foundation stresses that may lead to a separation failure. Thus, a simple single DOF model has been chosen.

**B.4.2.1 Bottom-Supported Structures**

The offlead and sidelead forces determined in paragraph 4.1.2.2 of this Specification 2C, combined with an appropriate wind loading, provide a good dynamic rating procedure that should adequately cover operations where skilled crane operators are involved. The formulas in paragraph 4.1.2.2 provide a means of assessing dynamic rated load, sideload, and offload as a function of significant wave height. The amount of dynamics increases as the significant wave height increases, providing a rational means of determining the associated reduction in crane rated load.

The second method for establishing dynamic coefficients, as described in paragraph 4.2.1.2, requires purchaser specification of offlead, sidelead, and vertical deck motions. This requires some degree of sophistication on the purchaser's part and a great deal of site-specific information, since this information is not generally available. Several methods are available to obtain this data, including (1) direct measurement of deck velocity at the platform, (2) motion studies for vessels at sea, or (3) water surface velocity calculations based on sea state. The third option is easiest and most widely used. As an example, Table B1 shows one correlation of velocity to sea state, excerpted from SAE J1238. Other correlations are available.

The parameter \( V_d \) tabulated in Table B1 was added to provide an estimate for the cargo deck velocity required in computing the dynamic coefficient \( C_b \). As explained in SAE J1238, the factor

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1.577 was chosen from a normal distribution to provide a 90% probability that the next wave will have a velocity less than \( V_d \).

In addition to determining deck velocity for a site-specific evaluation, the purchaser should determine desired wind speed, offlead, and sidelead to be considered in the dynamic rating chart.

The third method for establishing a dynamic coefficient, as described in paragraph 4.2.1.3, is adoption of a uniform factor for all off-platform lifts. This has substantial operational advantages in simplifying rating charts and their use. The dynamic coefficient must be large enough to account for the most severe operating sea conditions, yet not substantially hamper crane capabilities in normal use. Therefore, this method is reasonable only in areas where mild sea conditions predominate, such as the Gulf of Mexico. A rating system of this type—using a dynamic coefficient of 2.0 with zero offlead, sidelead, and wind speed—has been used in the Gulf of Mexico with good results. Using the deck velocity correlation from SAE J1238 for a tethered boat and a Beaufort Wind Force of 5, also yields a factor of about 2.

B.4.2.2 Floating Structures

Calculation of dynamic coefficients for cranes on floating structures is a more complex problem than the fixed structure problem. The purchaser is required to provide more information. The data required relate to vessel motions and should be within the purchaser's ability to provide.

B.5.1 Analysis

In applying the AISC Specification\(^1\) to cranes specifically, the design engineer is faced with making certain interpretations regarding functional differences of certain structural members on cranes compared to their counterpart in a building. This is particularly true in the case of the boom in regard to allowable compressive stresses, which AISC expresses in terms of the effective length factor (\( K \)) in regard to elastic buckling.

The numerical value of \( K \) is appropriately left to the design engineer, however, not without a sound engineering basis. For cranes with boom lines attached at the boom-tip, the factor for buckling in the vertical plane is \( K = 1.0 \) and for buckling out of the vertical plane the conservative assumption is \( K = 2.0 \) (for a "flagpole"). However, an assumed value of \( K = 2.0 \) for "out of plane" buckling can be overly conservative, especially for long booms. The correct effective length factor can be computed, but not in a simple or direct manner, as it is a function of resistance to sideload from the high-tension lines and this resistance increases with increasing load being lifted\(^2\). The procedure is generally implemented with the aid of a computer and, as a result, design curves are not readily available. Also required, in the computation of \( K \) for the overall boom, is the computation of an average moment of inertia required in arriving at a radius of gyration, for use in the AISC Specification. Methods for computing average moment of inertia of a laced column are available in the literature\(^3\) \(^4\).

Effective length factors of individual boom components, i.e., unbraced portions of chords, and lacing members, must also be considered. Here again the design engineer can choose conservative values or he can perform buckling analyses (using finite element models) of the chord/lacing structural system. This type of analysis (finite element) is necessary to properly employ the AISC Specification in the case of booms with lacing not meeting the requirements of paragraph 1.18.2.6,

\(^1\) AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings, latest edition


\(^3\) Guide for the Analysis of Guy and Stiffleg Derricks, American Institute of Steel Construction, 1974.

1.18.2.6 Lacing, including flat bars, angles, channels, or other shapes employed as lacing, shall be so spaced that the ratio l/r of the flange included between their connections shall not exceed the governing ratio for the member as a whole. Lacing shall be proportioned to resist a shearing stress normal to the axis of the member equal to 2 percent of the total compressive stress in the member.

The ratio l/r for lacing bars arranged in single systems shall not exceed 200. Double facing bars shall be joined at their intersections. Lacing bars in compression may be treated as secondary members, with l being taken as the unsupported length of the lacing bar between fasteners or welds connecting it to the components of the built-up member for single lacing and 70 percent of that distance for double lacing. The inclination of lacing bars to the axis of the member shall preferably be not less than 60 degrees for single lacing and 45 degrees for double lacing. When the distance between the lines of fasteners or welds in the flanges is more than 15 inches, the lacing shall preferably be double or be made of angles.

Gantrys and A-frames should also be analyzed with regard to bending moments occurring at the braces. This is generally achieved with the use of finite element models.

B.5.1.4 Fatigue

Appendix B of the AISC Specification provides fatigue design criteria for typical structural connections, various types of welds and several ranges of loading cycles. The 25,000 cycles of design load, chosen as a minimum, is not to be construed as a representative number of loading cycles for offshore cranes, but rather as the lowest acceptable number of cycles to be used for design. The Specification 2C Task Group was unable to produce a workable guideline on duty cycles of offshore cranes because of the wide range of applications. Therefore, it remains the responsibility of each crane manufacturer to design their product in accordance with its expected usage, and of each crane purchaser to inform the manufacturer of any special requirements regarding duty cycle.

The treatment of hot spot stresses, as discussed in this Specification 2C, was adopted from API RP 2A. Although that treatment was developed for tubular connections, the Specification 2C Task Group feels that it can be applied to offshore cranes as well, especially for non-typical connections which may exceed the scope of AISC Appendix B, and for welds which rely on length rather than cross-section, for the transfer of load.

B.6.1 Design Authentication

The manufacturer shall ensure that this design method does not change between models or cranes without re-performing design authentication testing. In that regard, it is recommended that the design procedure be well documented and complete. Many factors influence the strength of crane structures including material properties, weld strengths, lacing size and angle, and transition details in areas of stress concentrations. Any modification to a crane critical structural component should be documented by the manufacturer as meeting the standard design method or should be re-tested for design authentication.

B.6.1.1 Resistance Type Strain Gauge Test

An example procedure, for crane strain gauge testing is given in SAE J987 for cranes of Type

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1 API RP 2A-WSD: Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms—Working Stress Design, December 2000, Section 5, Figure 5.4-1—Fatigue S-N Curves.
2 SAE J987: Rope Supported Lattice-Type Boom Crane Structures—Method of Test
C, D, or E from Figure 1 of this Specification 2C. An example procedure for cranes of Type A or B is given in SAE J1063\(^1\). These procedures discuss test measurements, gauge readings, procedures, and loading conditions typical for crane structures. They provide a good reference for typical crane test procedures.

**B.7.2.4 Wire Rope—Design Factors**

Wire rope is an expendable item and is routinely replaced in accordance with criteria set out in API RP 2D\(^2\). It also has variable load-life characteristics that significantly differ from the more or less permanent components of the crane. Because of this and the many other inherent properties peculiar to wire rope, it was decided to set singular design factors taking into consideration each type rope and rope service. The design factors have been increased and, based on experience, are sufficiently large to account for minor strength effects such as specified sheave sizes, tackle dynamics and nominal vs. minimum rope strength.

**B.7.4.2 Wire Rope—Inspection, Maintenance and Replacement (IMR)**

The present rejection or replacement criteria in API RP 2D were established for the more conventional or standard construction wire ropes and does not appropriately consider the less predictive failure characteristics of rotation-resistant type ropes. In addition to the IMR guidelines set out in API RP 2D—and until such time as API RP 2D has been modified to include special inspection criteria for this non-standard construction rope—rotation-resistant rope operation under API Specification 2C design factors should be replaced when there are four randomly distributed broken wires in one lay or two broken wires in one strand in one lay. Limited non-personnel usage may continue until there are six randomly distributed broken wires in one lay or three broken wires in one strand in one lay if the load is restricted to maintain a design factor of 10.0.

**B.7.4.1 Minimum Sheave Ratios**

Minimum sheave ratios have been increased for boom hoist systems because of the heavy use of that system in pedestal-mounted cranes. Note that the D/d ratio continues to use pitch diameter as opposed to root or tread diameter.

**B.8.1.6 Comparative Power Rating**

The comparative power rating (CPR) is intended to provide to the purchaser an indication of the relative life of different hoist units when operated under similar conditions. This is done by providing a uniform method of rating calculation.

An insufficient data base exists for offshore operations in which to develop a rigid design standard incorporating duty cycles, i.e., horsepower ratings, such as exists with industrial overhead hoists. Overhead hoists are generally classified and rated in accordance with specifications such as those found in ASME HST-4\(^3\). These specifications normally divide hoist applications into five groups based on anticipated duty cycle. The CPR adopted by the API is based on the H3 (Mid-Range Application) designation in the above document.

**B.14 Material Requirements for Structural Components**

Material requirements are specified herein to minimize failures of critical components whose fracture would result in loss of load or structural instability. It is intended that crane designers consider the significance of individual components and establish the criticality of each. These requirements are not intended to apply to components whose fracture would be considered a

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\(^1\) SAE J1063: Cantilevered Boom Crane Structures—Method of Test  
\(^2\) API RP 2D: Recommended Practice for Operation and Maintenance of Offshore Cranes, latest edition  
\(^3\) ASME HST-4: Performance Standard for Overhead Electric Wire Rope Hoists
nuisance or inconvenience (e.g., band rails, cab enclosures, deck plating, etc.) but only components of the structural load transfer system. The properties and requirements for wire rope are detailed elsewhere and are not a part of these paragraphs.

B.14.1 Materials

The vast majority of crane designs are based on well-founded engineering principles and manufacturing details are generally shown in detail on the resultant engineering drawings. Frequently, the material properties and strength requirements employed in the design considerations are lacking on the engineering drawings and are absent in documentation available to manufacturing personnel. The requirements of this paragraph are for the purpose of assuring consideration of the material properties to be used in critical components and the development of material specification based on those considerations.

B.5.3 Traceability

The traceability requirements minimize the inadvertent use of unintended or inappropriate materials for manufacture of critical components. Insistence upon traceability to the producers control parameter further minimizes errors in material usage resulting from clerical errors and unscrupulous certifications by third party material suppliers. When material traceability or identification is lacking, the crane manufacturer may elect to determine the properties of such materials by conducting tests within its own laboratories or in an outside facility. If the tests conducted by the crane manufacturer prove the materials of unknown origin conform to the manufacturer's design criteria, the test reports provide the documentation to justify use of the materials.

B.14.3 Fracture Toughness

Sudden or catastrophic failure of critical components is minimized by employing materials with sufficient fracture toughness to tolerate any inherent imperfections resulting from manufacturing or fabrication.

Indexing the Charpy impact energy requirements to the transition temperature provides a margin of safety against small flaw brittle fracture initiation at higher temperatures. For service exposures with frequent recurrence at or near the transition temperature, toughness requirements should be increased, the critical components protected from the low temperature exposure, or the design service temperature lowered to avoid frequent exposures to the transition temperature.

Brittle fracture occurs when the interdependent parameters of tensile stress, fracture toughness, and material imperfection exist in a critical combination. Of the three, fracture toughness is the parameter determined with greatest reliability. Determination of imperfection size by available nondestructive inspection techniques and assessment of actual stresses resulting from concentration factors and fabrication residuals is accomplished with less precision. Materials subjected to controlled thermal stress relief treatments are excluded from the small flaw fracture initiation category if the design considerations have accounted for stress concentration factors; i.e., the actual applied stresses are within commercial design codes.

Use of materials with brittle properties may be justified by designs that incorporate sufficient redundancy to assure continued safe operation of the machine should one or more of its members fail. Further justification for use of materials of uncontrolled fracture toughness can be provided by inspections and examinations to assure the materials are free of critical size imperfections and will remain free in subsequent service. For non-redundant components exposed to corrosive environments and cyclic stresses, design and manufacture of critical components using materials of known fracture resistance is the responsible engineering approach.

B.14.4 Castings
Structural components of complex shape are more readily produced by casting the part to final shape rather than machining from wrought shapes or by forging to the approximate final form. Sound steel castings exhibit properties comparable to their wrought counterpart. The soundness of castings depends, largely, on the foundry practice, particularly the initial procedures to feed the flask with hot metal. The validity of the pouring procedure is verified either by destructive sectioning of a prototype casting to reveal potential shrinkage, porosity, sand and dross entrapment, etc., or by nondestructive examinations capable of disclosure and definition of imperfections in all critical areas of the casting. Radiography is the traditional technique for this purpose and graded standards or acceptance have been developed by the American Society for Testing Materials for use in selecting the quality level compatible with the design criteria.

Prototype examinations indicate sound casting practices are not an assurance all castings produced by the procedure will exhibit equal quality; therefore, the prototype procedures should be developed to assure acceptable soundness under routine foundry practice. The acceptance criteria specified in Table 5 is for that purpose. Specification of these quality levels does not result in delivery of castings free of all imperfections, nor does it impose requirements beyond the capabilities of commercial foundries. The crane designer is encouraged to become thoroughly familiar with the imperfections permitted by these requirements and assess the significance on the individual design reliability.

Resistance of castings to brittle fracture is improved by the absence of residual solidification and cooling stresses. Controlled cooling of castings following the solidification results in significant reductions in residual stresses; however, castings removed from the mold at elevated temperatures above the steel's transformation temperature and cooled rapidly to enhance strength properties can result in significant residual stress levels. Shakeout procedures for control of properties and residual stresses are often poorly controlled at the foundry necessitating a subsequent thermal treatment under controlled conditions.

### B.14.5 Fasteners

Fasteners subjected to high tensile and/or dynamic loading are potential brittle fracture candidates due to inherent notch effects of thread geometry. Crane designers should assess the criticality of all bolted connections and consider the advantages of specifying round-bottom or rolled-thread profiles.

Fasteners of critical classification are required herein to possess a minimum strength level and adequate fracture toughness to minimize fracture initiating at fatigue cracks resulting from cyclic loading and/or corrosion pitting from exposure to the marine environment. When fasteners of higher strength than attainable from the specification of ASTM A 320/A 320M are employed, selections shall be justified by design considerations and testing to assure compliance with the design requirements.

For service design temperatures approaching zero degrees Fahrenheit (minus 17.8° C), the crane designer should consider more stringent fracture toughness requirements as compensation for the thread stress concentration factors and the inherent propensity for brittle fracture in high strength steels.

For all critical fasteners, the designer should consider the provisions of paragraph 8.3.4 of this Specification 2C imposed on swing-circle fasteners and develop assembly specifications to assure proper installation and makeup of the fastener.

### B.14.6 Plate

Lamellar tearing of rolled plate was first documented as a failure mechanism shortly after the development of arc welding as a fabrication tool. The potential for failure by lamellar tearing became
Research by British investigators related the mechanism of lamellar tear to nonmetallic inclusions retained from the steel making process. Laboratory investigations and mill test procedures were correlated to define a mechanical property could be employed as an acceptance tool for procurement of plate resistant to lamellar tearing. The tool was found in a simple tensile test conducted on specimens removed from the through thickness direction of the plate.

Steel makers have developed methods of reducing the density, size and shape of residual nonmetallic inclusions which permits loading of the plate in the through thickness direction without significant hazards of lamellar tearing.

Specification of the through thickness tensile test requirement on procurement of plate together with ultrasonic examinations provide assurance that the material has a low level of nonmetallic inclusions as well as freedom from large laminations resulting from ingestion of other contaminants or from rolling practice.

Crane design engineers should evaluate all design details which result in loading in the through thickness direction and either modify the detail to eliminate through thickness loading or prepare procurement specification employing the additional performance requirements detailed in this paragraph.

B.15 Welding of Critically Stressed Components

The performance of critical welded components of the crane is contingent upon welding procedures that develop the strength and fracture toughness of the materials joined by the welding. The ability of the welders to apply the provisions of the procedures is assured by examination and performance tests outlined by the referenced welding standards organizations.

B.15.2 Welding Procedures

Written welding procedures are essential to control of critical member fabrications. Procedures should be in sufficient detail and clarity to be readily interpreted by shop fabrication personnel. The prequalified procedures described in the American Welding Society specifications are reliable for joining steels of known weldability and those listed in the specifications. These procedures will generally yield acceptable results on the tabulated materials and need not be proven by actual laboratory testing. The performance of these procedures for welding alloy steels and others unlisted in the specifications is uncertain. For these steels, laboratory testing is specified to assure the procedures employed will yield satisfactory results.

B.15.3 Welder Performance

The manipulative skills of welders can be ascertained by radiography or by destructive bend testing when welding processes are employed with known characteristics devoid of a propensity to produce fusion and other planar type defects. When welders are to be qualified on short-circuiting (short-arc) gas metal arc welding, destructive bend testing is employed to detect the presence of planar imperfections which be inherent in the use of the process.

B.15.4 Welding Properties

The American Welding Society specifications provide minimum guidance for assessment of procedures for welding fracture-controlled materials. When developing procedures for the joining of fracture resistant materials, the requirements of the American Society of Mechanical Engineers should be employed with fracture toughness testing imposed on the weld and heat-affected zones. Charpy impact testing is the traditional sampling technique; however, the crane manufacturer utilizing a fitness-for-purpose design philosophy may wish to substitute crack opening displacement or plane
strain fracture toughness testing for the Charpy tests.

**B.16 Nondestructive Examination**

Nondestructive examinations provide some added assurance that critically stressed components and fabrications are free of imperfections capable of initiating fractures. The extent of examination and the imperfection acceptance limit are considerations dependent on material properties, design stress levels, structural redundancy, and criticality of the component. These considerations are an integral part of the design process, and form the basis on which control personnel develop the operating procedures for inspections and examinations to be conducted during the course of manufacturing and fabrication.

**B.16.1 Nondestructive Examination Procedures**

The applicability of method and extent of inspection are essential factors in the validity of any nondestructive examination program. Radiographic examinations are effective in the detection of internal three-dimensional imperfections in castings and butt welds. The method is less effective in the detection of planar imperfections such as cracks and lack of fusion or in the examination of tee butt configurations, which limit optimum orientation of the radiation beam and film placements. Ultrasonic examination techniques yield more reliable results in the detection of planar imperfections provided the procedure employed results in a perpendicular interception of the sound beam and imperfection. Magnetic particle examinations are equally sensitive to the orientation of the magnetic field with respect to the imperfection orientation and for practical purposes can be relied upon only for detection of surface or near surface defects. The reliability of liquid penetrant techniques, also limited to surface defect detection, is influenced strongly by surface contaminants such as oil and grease. Inadequate cleaning, insufficient penetrant dwell time, poor excess penetrant removal, and improper developing techniques all influence the reliability of the technique.

These factors should be considered by the crane manufacturer's engineering and quality control personnel in the development of non-destructive examination procedures to obtain the optimum results possible from the attributes of each available method. The procedures and specification requirements of the ASME Boiler and Pressure Vessel Code, Section V—Nondestructive Examination provide an excellent source of information for development of working nondestructive examination procedures.

Conducting the examinations immediately following processing which can introduce new material imperfections eliminates potential entry of imperfect materials into the manufacturing system and minimizes waste of available manpower expended on work later to be discarded.

**B.16.2 Nondestructive Examination Personnel Qualifications**

Present commercial practice for nondestructive examination personnel competency verification places responsibility for the verification on the manufacturer. The commercial practice is contained in a recommended practice published by the American Society of Nondestructive Testing, which details requirements for personnel education, training, and certification. In addition to verification of captive employees, these recommendations are equally applicable to personnel employed on a contract basis. Regardless, the manufacturer retains responsibility for the contractor's competency.

The unique features of tubular member truss structures require the use of corrections and procedures not common in the ultrasonic examination of plate and rolled shape welding. The American Petroleum Institute recognized these added requirements and developed a recommended practice to qualify personnel using these techniques. When the ultrasonic technique is used for this purpose, the API recommendations for personnel verification are appropriate.

**B.16.3 Nondestructive Examination Personnel Qualifications**
When nondestructive examinations are based on fitness-for-purpose design philosophies, the choice of examination methods and acceptance criteria are functions of materials properties, magnitude and direction of stress, and the anticipated accuracy in flaw size measurement. These factors are to be determined by documented testing of materials and appropriate calculations of acceptable flaw sizes based on recognized fracture mechanics methodology.

**B.16.4 Examples of Workmanship Standards**

Paragraph 15.4 of this Specification 2C illustrates some components of cranes, which may be considered critical in some designs, together with applicable methods of examinations and appropriate acceptance criteria. Each crane manufacturer should assess its designs for application of these examinations. Consideration of load applications (tension, shear, compression) is pertinent to the decision to use these examinations and acceptance criteria. The basis of the decisions should be documented and available for review by the purchaser.
1. ATTENDANCE:

Peter Marshall - Moonshine Hill Pty. -- Robin Gordon - Edison Welding
chairman                    Institute
Peter Sandy - Marathon - site host  Bill Fazackerley - Microalloying Inc.
Joe Kiefer - Conoco          Jim Smith - Shell
Gene Bickford - McDermott   Jeff Post

2. MARK-UP OF BEAM SPEC 2MT2

Draft “E”, resulting from our discussion, is being distributed following these minutes.

The substantive changes are briefly summarized below:

- 1.5 – new reference to international specs
- 2.2 – added FHWA heat straightening reference
- 4.1 – delete open hearth
- 4.6 add grain size, define frequency
- 4.7 heat straighten by agreed procedure, FHWA optional
- 5.1 re-word heat analysis; report any element knowingly added
- Table 1: 0.50 Ni max for class A
- define freq H; sample flange or thickest outstand
- spell out S1 and S2 per A6
- lower charpy temp becomes S3
- S5-star --> S102 (far out)
- S9 broaden title
- S19 new title
- S19.1 deleted
- renumbered S19.1.2 redefine quality plan
- new S20 incorporates old S19.4 thru S19.6.2
- old S19.7 deleted
- S101.1 list updated

Jeff Post confirmed the feasibility of using heat straightening to restore A6 tolerances after corrective normalizing.

Peter Sandy reminded us that the new standard will be subjected to QC color coding after the letter ballot, and may be returned to us for correction.

green    = auditable requirement
blue     = informative
red = commercial problem
yellow = ambiguous

3. FUTURE MEETINGS:

July 17, Houston, CANCELLED.
   Final comments on Spec 2MT2 will be handled by Email.

August, date TBA.
   First look at Centerline Segregation RP.
   Feedback from SC2 meeting.
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