



# SURFACE VEHICLE STANDARD

J987™

NOV2019

Issued 1967-05  
Reaffirmed 1994-04  
Revised 2019-11

Superseding J987 AUG2012

## Lattice Boom Cranes - Method of Test

### RATIONALE

Revisions have been made to the following sections:

- Updated Section 1 from “rope supported” to “pendant supported.”
- Updated Section 1 from “luffing type” to “luffing jib type.”
- Updated Table 1 header from “luffing attachment” to “luffing jib.”
- Updated Table 1 in throughout from “luffing boom” to “boom.”
- Updated 6.5 from “ASTM 251-67” to “ASTM E251.”
- Updated Table 1 tests H, K, and N to include offsets for boom top to jib butt and jib sheave to jib centerline.
- Updated Table 2 test J to include offsets for boom top to jib butt and jib sheave to jib centerline.
- Updated 8.9 designation for the note was removed from second paragraph because paragraph contained a normative requirement.
- Updated 9.2.2 Table 1 reference to Table 2 for conventional cranes.
- Updated 9.2.2.b. equation reference from Equation 7 to Equation 5.
- Added Figure 3 to 9.2.2 in relation to Table 2 test J update.
- Added  $Y_H$  and  $Y_S$  to Appendix A in relation to Figure 3.
- Updated from “must” to “shall” in 5.3, 6.5, 8.9, Appendix B in two locations, and Appendix C in three locations.
- Updated from “may” to “should” in 4.1 in four locations: 6.6, 7.5, 9.1, 9.2.2, and Appendix C.

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## 1. SCOPE

This SAE Standard applies to mobile construction-type lifting cranes utilizing pendant-supported, conventional, and luffing jib type lattice boom crane structures.

### 1.1 Purpose

The purpose of this test method is to provide a systematic nondestructive procedure for determining the stresses induced in crane structures under specified conditions of static loading through use of resistance-type electric strain gages, and to specify appropriate acceptance criteria for specified loading conditions.

## 2. REFERENCES

### 2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

#### 2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), [www.sae.org](http://www.sae.org).

SAE J1028      Mobile Crane Working Area Definitions

SAE J1093      Latticed Crane Boom Systems - Analytical Procedure

#### 2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, [www.astm.org](http://www.astm.org).

ASTM E251      Test Methods for Performance Characteristics of Bonded Resistance Strain Gages

#### 2.1.3 Column Research Council Publications

Available from Column Research Council, Cushing-Malloy, Inc., Ann Arbor, MI, 1960.

Guide to Design Criteria for Metal Compression Members

#### 2.1.4 Joseph Marin Publications

Available from Prentice-Hall, Inc., Englewood, NJ, 1962.

Mechanical Behavior of Engineering Materials

### 3. DEFINITIONS

See Appendix A.

#### 3.1 STRAIN ( $\epsilon$ )

Deformation of material at any given point with respect to a specific plane passing through that point, expressed as change in length per unit length.

#### 3.2 STRESS (S)

The intensity of internal force accompanying strain, expressed in force per unit area. For purposes of this test method, stress is related to measured strain by the uniaxial stress equation (see Equation 1):

$$S = E \cdot \epsilon \text{ (within proportional limits)} \quad (\text{Eq. 1})$$

where:

S = stress

E = modulus of elasticity, for the material involved

$\epsilon$  = strain

NOTE: The simple uniaxial stress formula may not be sufficiently accurate for some areas of crane structures under biaxial stress, and special consideration should be given in such cases (see Appendix B).

#### 3.3 YIELD POINT ( $S_y$ )

The stress at which a disproportionate increase in strain occurs without corresponding increase in stress. For purposes of this code, yield point is to be considered as the minimum 0.2% offset tensile yield point or yield (ASTM A370) strength specified by the appropriate standard for the material used.

#### 3.4 CRITICAL BUCKLING STRESS ( $S_{cr}$ )

The average stress which produces an incipient buckling condition in column-type members (see Appendix C).

#### 3.5 INITIAL REFERENCE TEST CONDITION

The defined no-stress or zero-stress condition of the crane structure after the “break-in” (see 7.3) as established by: (a) supporting the structure on blocking to minimize the effects of gravity, or (b) the crane structure components in an unassembled state or any alternate method that will establish the zero-stress condition. Under this condition, the initial reference reading for each gage is obtained,  $N_1$ .

#### 3.6 DEAD LOAD STRESS CONDITION (DL)

The completely assembled crane structure on the test site and in the position or attitude, ready to apply the specified live load at the specified radius. Under this condition, the second reading for each gage is obtained,  $N_2$ .

NOTE: Although the hook, block, slings, etc., are considered part of the suspended load, for purposes of safety and practicality, they may be supported by the crane when this reading is taken.

#### 3.7 DEAD LOAD STRESS ( $S_1$ )

The stress computed as defined in 3.2 by using the difference in the readings obtained in 3.6 and 3.5 for each gage ( $N_2 - N_1$ ).

### 3.8 WORKING LOAD STRESS CONDITION

The completely assembled crane structure on the test site and in the specified position, supporting the specified rated load. Under this condition, the third reading for each gage is obtained,  $N_3$ .

### 3.9 WORKING LOAD STRESS ( $S_2$ )

The stress computed as defined in 3.2 by using the difference in the readings obtained in 3.8 and 3.5 for each gage ( $N_3 - N_1$ ).

### 3.10 RESULTANT STRESS ( $S_r$ )

The maximum stress induced in the structure as a result of dead load stress ( $S_1$ ) or the working load stress ( $S_2$ ), whichever is greater in absolute magnitude.

#### 3.10.1 COLUMN AVERAGE STRESS ( $S_{ra}$ )

The direct compression stress in a column or the average stress computed from the several gages located at the section (see Appendix C).

#### 3.10.2 COLUMN MAXIMUM STRESS ( $S_{rm}$ )

The maximum compression stress in a column computed from the plane of buckling as established from the several gages located at the section (see Appendix C).

### 3.11 LOADINGS

The application of weights and/or forces of the magnitude specified under the condition specified.

### 3.12 SPECIFIED

The stated requirements of the manufacturer, the user, the testing agency, or any agreement between these parties.

## 4. APPLICATIONS

- 4.1 This test method is intended to describe the approximate maximum loading conditions to which any component of the entire load-supporting structure of a crane is subjected. In some cases, a more severe loading condition(s) may be indicated by analysis. In these cases, the more severe condition(s) should be added to or substituted for the specified test loading condition(s). It also classifies stress area Types I, II, III, and IV (see 9.1), and defines limits for each class. Results should be used to correlate boom calculation results for Class III stress areas as given, e.g., by SAE J1093 boom calculation method. Test results for Class I stress areas throughout the structure should be used to check any available calculations. This test method evaluates Class II stress areas for which calculations are seldom available. Class IV stress areas, where disproportionately high stress readings can occur, should be reviewed for better insight by calculation methods.
- 4.2 This method applies to load-supporting structures as differentiated from power transmitting mechanisms. It is restricted to measuring strains under static conditions.
- 4.3 The procedures outlined are intended to supplement basic design analysis. One such method of analysis for crane boom systems is presented in SAE J1093. The relationship of this test method to calculations as presented in SAE J1093 is as follows:
  - 4.3.1 A production boom system (serially produced) can be rated by the methods outlined in SAE J1093, but a prototype of this system should be subjected to the following test procedures as documentation of its capability.

- 4.3.2 A production boom system that has been rated by the methods of 4.3.1 may be used on another machine without retesting by the methods specified herein. This can be done only if the same analytical procedure shows its stress levels will be less than in the original application and provided the supporting structure is as rigid as the original mounting. Rigidity of the supporting structure is determined by the change in the slope of the boom foot axis (see 8.5) as test loads are applied.
- 4.3.3 A specially designed boom system (not serially produced) similar to a known and tested design may be rated by the methods of SAE J1093. The applicable overload test conditions specified (see Tables 1 and 2) should also be applied as proof of competence.

**Table 1 - Luffing jib type crane - test conditions**

| Test | Test Conditions First Select                                                                 | Test Conditions Notes            | Test Conditions Then Apply Working Load                                                             | Test Conditions Then Apply Overload                                                    | Purpose is to Test                                  | Tested Components and Strength Margins** Under-Carriage | Tested Components and Strength Margins** Upper Structure | Tested Components and Strength Margins** Boom and Jib(s) | Tested Components and Strength Margins** Suspension (Except Ropes) |
|------|----------------------------------------------------------------------------------------------|----------------------------------|-----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|-----------------------------------------------------|---------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|--------------------------------------------------------------------|
| A    | Max numerical rated load at its longest rated radius. Use longest boom rated with this load. | 2<br>9<br>16<br>17               | (Y) RL with upperstructure in any position.                                                         | (Z) 1.25 RL or tipping load, whichever is less.                                        | Integrity boom, luffing jib, and upperstructure.    | —                                                       | Y,Z                                                      | Y,Z                                                      | —                                                                  |
| B    | Max (RR x RL) with largest rated load allowed at this load moment.                           | 3<br>6<br>8<br>12<br>17          | (Y) RL and SL (0.02 x RL) both left and right. Orient upperstructure to any position.               | (Z) 1.25 RL or tipping load, whichever is less. Orient upperstructure to any position. | Upper structure and suspension for max load moment. | —                                                       | Y,Z                                                      | —                                                        | Y,Z                                                                |
| C    | Max (RR x RL) over side, with largest rated load allowed at this load moment.                | 1<br>3<br>5<br>6<br>7<br>8<br>17 | (Y) RL and position upperstructure in allowed rotation range to obtain max strain in member tested. | (Z) 1.25 RL or tipping load, whichever is less. Orient upperstructure to any position. | Undercarriage for max load moment.                  | Y,Z                                                     | —                                                        | —                                                        | —                                                                  |
| D    | Max (RR x RL) over end, with largest rated load allowed at this load moment.                 | 1<br>3<br>5<br>6<br>7<br>8<br>17 | (Y) RL and position upperstructure in allowed rotation range to obtain max strain in member tested. | (Z) 1.25 RL or tipping load, whichever is less. Orient upperstructure to any position. | Undercarriage for max load moment.                  | Y,Z                                                     | —                                                        | —                                                        | —                                                                  |

| Test | Test Conditions First Select                                                                                                                                                                    | Test Conditions Notes      | Test Conditions Then Apply Working Load                                                | Test Conditions Then Apply Overload                                                  | Purpose is to Test                                | Tested Components and Strength Margins** Under-Carriage | Tested Components and Strength Margins** Upper Structure | Tested Components and Strength Margins** Boom and Jib(s) | Tested Components and Strength Margins** Suspension (Except Ropes) |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|---------------------------------------------------|---------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|--------------------------------------------------------------------|
| E    | Rated radius which produces max (RR x RL). Use boom with longest luffing jib, which has a rating at this radius.                                                                                | 13<br>14<br>15<br>16<br>17 | (Y) RL and SL (0.02 x RL) both left and right, upperstructure over a corner.           | (Z) 1.25 RL or tipping load, whichever is less. Orient upperstructure over a corner. | Integrity of boom, luffing jib, and suspension.   | —                                                       | —                                                        | Y,Z                                                      | Y,Z                                                                |
| F    | Longest combination of boom + luffing jib offered for each specified suspension.                                                                                                                | 4<br>16<br>18              | (X) Suspend boom, luffing jib, just clear of ground.                                   | None.                                                                                | Integrity of boom, luffing jib, and suspension.   | —                                                       | X                                                        | X                                                        | X                                                                  |
| G    | Longest combination of boom + luffing jib offered for each specified suspension.                                                                                                                | 13<br>14<br>15<br>16       | (Y) RL at min RR and SL (0.02 x RL) both left and right, upperstructure over a corner. | (Z) 1.25 RL or tipping load, whichever is less. Orient upperstructure over a corner. | Integrity of boom, luffing jib, and suspension.   | —                                                       | —                                                        | Y,Z                                                      | Y,Z                                                                |
| H    | Max (luffing jib RL x L <sub>JL</sub> x sinβ + Y <sub>H</sub> + Y <sub>S</sub> * cosβ). Use longest luffing jib where this condition exists. Then select longest boom for the above conditions. | 11<br>13<br>14<br>15<br>16 | (Y) RL at max RR and SL (0.02 x RL) Both left and right, upperstructure over a corner. | (Z) 1.25 RL or tipping load, whichever is less. Orient upperstructure over a corner. | Integrity of boom under condition of max torsion. | —                                                       | —                                                        | Y,Z                                                      | —                                                                  |

| Test | Test Conditions First Select                                                                                                                                                                                  | Test Conditions Notes            | Test Conditions Then Apply Working Load                                                 | Test Conditions Then Apply Overload                                                  | Purpose is to Test                                                         | Tested Components and Strength Margins** Under-Carriage | Tested Components and Strength Margins** Upper Structure | Tested Components and Strength Margins** Boom and Jib(s) | Tested Components and Strength Margins** Suspension (Except Ropes) |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|----------------------------------------------------------------------------|---------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|--------------------------------------------------------------------|
| I    | Fixed Jib Test:<br>Longest combination of boom, luffing jib, and fixed jib(s) for each specified suspension with min fixed jib offset.                                                                        | 4<br>10<br>11<br>16<br>18        | (X) Suspend boom and jib(s) just clear of ground.                                       | None.                                                                                | Integrity of boom, luffing jib, fixed jib, upperstructure, and suspension. | —                                                       | X                                                        | X                                                        | X                                                                  |
| J    | Fixed Jib Test:<br>Longest combination of boom, luffing jib, and fixed jib(s) for each specified suspension with min fixed jib offset.                                                                        | 10<br>11<br>13<br>14<br>15<br>16 | (Y) RL at min RR and SL (0.02 x RL) both left and right, upperstructure over a corner.  | (Z) 1.25 RL or tipping load, whichever is less. Orient upperstructure over a corner. | Integrity of boom, luffing jib, and fixed jib.                             | —                                                       | —                                                        | Y,Z                                                      | —                                                                  |
| K    | Fixed Jib Test:<br>Max (fixed jib RL x $F_{JL} \times \sin\beta + Y_H + Y_S \times \cos\beta$ ). Use longest fixed jib where this condition exists. Then select longest luffing jib for the above conditions. | 11<br>13<br>14<br>15<br>16       | (Y) RL at max RR and SL (0.02 x RL) both left and right, upper structure over a corner. | (Z) 1.25 RL or tipping load, whichever is less. Orient upperstructure over a corner. | Integrity of luffing jib and fixed jib.                                    | —                                                       | —                                                        | Y,Z                                                      | —                                                                  |

| Test | Test Conditions First Select                                                                                                                                                                          | Test Conditions Notes          | Test Conditions Then Apply Working Load                                                                          | Test Conditions Then Apply Overload                                                    | Purpose is to Test                                 | Tested Components and Strength Margins** Under-Carriage | Tested Components and Strength Margins** Upper Structure | Tested Components and Strength Margins** Boom and Jib(s) | Tested Components and Strength Margins** Suspension (Except Ropes) |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------|---------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------|--------------------------------------------------------------------|
| L    | Midfall Test:<br>Max numerical rated load at its longest rated radius. Use longest luffing jib rated with this load.                                                                                  | 13<br>15<br>16                 | (Y) RL and SL (0.02 x RL) both left and right. Orient upperstructure to any position.                            | (Z) 1.25 RL or tipping load, whichever is less. Orient upperstructure to any position. | Integrity of luffing jib, suspension, and midfall. | —                                                       | —                                                        | Y,Z                                                      | Y,Z                                                                |
| M    | Midfall Test:<br>Longest combination of boom + luffing jib offered for each specified suspension.                                                                                                     | 2<br>9<br>12<br>13<br>15<br>16 | (Y) RL and SL (0.02 x RL) both left and right at both max and min radius. Orient upperstructure to any position. | (Z) 1.25 RL or tipping load, whichever is less. Orient upperstructure to any position. | Integrity of luffing jib, suspension, and midfall. | —                                                       | —                                                        | Y,Z                                                      | Y,Z                                                                |
| N    | Midfall Test:<br>Max (midfall RL x MFL x sinβ + Y <sub>H</sub> + Y <sub>S</sub> * cosβ). Use longest fixed jib where this condition exists. Then select longest luffing jib for the above conditions. | 13<br>15<br>16                 | (Y) RL at max RR and SL (0.02 x RL) Orient upper structure to any position.                                      | (Z) 1.25 RL or tipping load, whichever is less. Orient upperstructure to any position. | Integrity of luffing jib, suspension, and midfall. | —                                                       | —                                                        | Y,Z                                                      | Y,Z                                                                |