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Enhanced Safety Crane Workshop

Review and Application of

ASME NOG-1-1998 & ASME NUM-1-2000

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May 15 -16, 2002

Scope

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- The intent of the workshop is to review the application of the ASME Nuclear Crane Standards. There are two published standards.
  - ASME NOG-1-1998, "Rules for Construction of Overhead Gantry Cranes (Top Running Bridge, Multiple Girder)"
  - ASME NUM-1-2000, "Rules for Construction of Cranes, Monorails and Hoists (with Bridge, or Trolley, or Hoist of the Underhung Type)"
  - Both provide requirements for enhanced safety equipment to minimize the potential for load drop accidents, or to minimize the effect of a handling incident.

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The ASME Nuclear Crane standards provide a basis for purchasing overhead handling equipment with enhanced safety features, based upon accepted engineering principles, and including performance and environmental parameters specific to nuclear facilities.

Scope

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- The documents are intended to standardize design, but not restrict innovation. They allow the use of standard commercial hardware where appropriate.
- Provides cost effective equipment to meet user needs.
- For additional information covering the overall scope of the ASME Nuclear Crane Standards refer to the technical paper ICONE-8544, ASME Nuclear Crane Standards for Enhanced Crane Safety and Increased Profit, by Stephen N. Parkhurst (provided in the handouts).

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The term "enhanced safety" to mean several things. The design and construction of a crane or hoist can be made less susceptible to catastrophic failure or more (structurally/mechanically) robust to minimize the effects of a handling incident by incorporating enhanced safety features. The enhanced safety features covered in ASME NOG-1 and NUM-1 include, higher design factors used in design methods, additional brakes on the hoist drum, a stringent quality control program during crane and hoist fabrication, a rigorist testing program before first time use of the equipment, and many others.

Scope

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- Topics we will cover
  - Common Crane Accidents (how a crane is vulnerable to an accident, so the design can provide "Enhanced Safety").
  - ASME Nuclear Crane Standards
    - ASME NOG-1-1998
      - Equipment covered by this standard
    - ASME NUM-1-2000
      - Equipment covered by this standard
  - Organization of NOG-1 and NUM-1
  - Establishing a crane as "Critical" or "Non-Critical"
  - The Single-Failure-Proof Concept
  - Application of ASME NOG-1 and ASME NUM-1
  - A Closer Look at Design

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The term "Single-Failure-Proof" is a Design philosophy where the "system design" allows any "single" component (e.g. along the hoist load path) to "fail" without catastrophic results (dropping a critical load). It is assumed, every component has the potential to fail. The design must accommodate these "single" component failures by incorporating a safety system (or other means) to prevent unwanted load movement or load drop.

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Common Crane Accidents

Common Crane Accidents

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- Review of common crane accidents, how a crane is venerable to a crane accident.
  - Most crane accidents are the result of the following:
    - Over Capacity Lift
    - Component Failure
    - Two Blocking
    - Load Hang-up
    - Snatching the load
    - Misreeving

- For additional information on common crane accidents refer to the technical paper ICONE-8077, X-Sam, The Single Failure Proof Crane System, by Jim Nelson (provided in the handouts).

In order to accomplish the review the ASME NOG-1 and ASME NUM-1, a basic understanding of how the typical crane accident occurs needs to be covered.

Common Crane Accidents

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- Over Capacity Lift
  - Hoist motor has the ability to lift a load greater than the load rating of the crane. A hoist motor can produce 180% - 275% of its rated torque (or more). These motors can produce this torque in a fraction of a second.
    - The brakes may not have the ability to hold this (over capacity) load or properly decelerate and stop a moving load.
    - Machinery alignment may be compromised due to excessive deflection of structural members, like the trolley load grit.
    - The mechanical components can be greatly overstressed.
  - Any of these items can lead to an accident or damage to the crane (sometimes damage is not reality detectable).
- Overload Limit Devices cannot protect against all overcapacity lifts conditions. The operator must prevent over capacity lifts.

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Some background material excerpted from CMAA Specification #70, Revised 2000:

4.3 Overload Limit Device

4.3.1 An overload limiting device is normal only provided when specified. Such a device is an emergency device intended to permit the hoist to lift a freely suspended load within its rated capacity, but prevents lifting of an overload that would cause permanent damage to a properly maintained hoist, trolley or crane.

4.3.1.1 Variables experienced within the hoist system, such as, but not limited to, acceleration of the loads, dynamics of the system, type and length of wire rope, operator experience, render it impossible to adjust an overload device that would prevent the lifting of any overload or load in excess of rated load.

4.3.1.2 The adjustment of an overload device, when furnished, will allow the lifting of an overload of such magnitude that will not cause permanent damage to the hoist, trolley, or crane and shall prevent the lifting of an overload of such magnitude that could cause permanent damage to a properly maintained hoist trolley or crane.

4.3.1.3 The overload device is actuated only by loads incurred when lifting a freely suspended load on the hook. ***Therefore, an overload device cannot be relied upon to render the hoist mechanism inoperative if other sources, such as but not limited to snagging of the load, two blocking of the load block, or snatching a load, induce loads into the hoisting system.***

4.3.1.4 The overload limit device is connected into the hoisting control circuit and, therefore, will not prevent damage to the hoist, trolley or crane, if excessive overloads are induced into the hoisting system when the hoisting mechanism is in a nonoperating of static mode.

Common Crane Accidents

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- Component Failure
  - Commercial hoisting equipment is designed such that catastrophic failure of one component (such as shafts, keyways, couplings, gearing) in the hoist "load path" will allow the load to fall.
    - Reasons for failure may include:
      - Improper design
      - Material failure, (improper material, material heat treatment)
      - Quality assurance during manufacturer (parts not built as designed)
      - Improper assembly, or machinery alignment
      - Improper inspection and testing before equipment first use so problems can be identified

Common Crane Accidents

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- Component Failure (continued)
  - Components such as shafts, couplings, gearing, etc. are designed with appropriate "design factors." this provides a margin to allow for variations in the properties of materials, manufacturing tolerances, operating conditions and design assumptions.
  - These "design factors" are there for a reason, they are not there to allow for lifting a load that is greater than the cranes rated capacity.
- Proper application of design factors during design, quality assurance during manufacturer, proper assembly and assignment of parts, testing of systems before first use, and proper in-service inspection and testing throughout the life of the equipment is needed to minimize risks associated with components failures.

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Excerpt from the Whiting Crane Handbook (4th Edition, ©1979):

Section VI, Part A, Design Factor

The "design factor" is often incorrectly called "factor of safety" in crane specifications. The term "factor of safety" is misleading in that it implies a level of protection greater than actually exists. It should not be used.

The "design factor" is a broader term in that it includes consideration of life expectancy and material characteristics as well as stress levels. The use of a design factor provides a margin to allow for variations in the properties of materials, manufacturing tolerances, operating conditions and design assumptions. Under no condition does it imply authorization or protection for users to load the crane beyond the rated load. Such practice is in violation of OSHA Standard 29CFR1910.179 and represents hazardous operation.

Common Crane Accidents

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- Two-Blocking
  - Two-blocking is the result of hoisting beyond the intended safe upper limit of hook travel to the point of solid contact between the load block and the upper block or hoist/trolley structure. The usual result is immediate failure of the wire rope.

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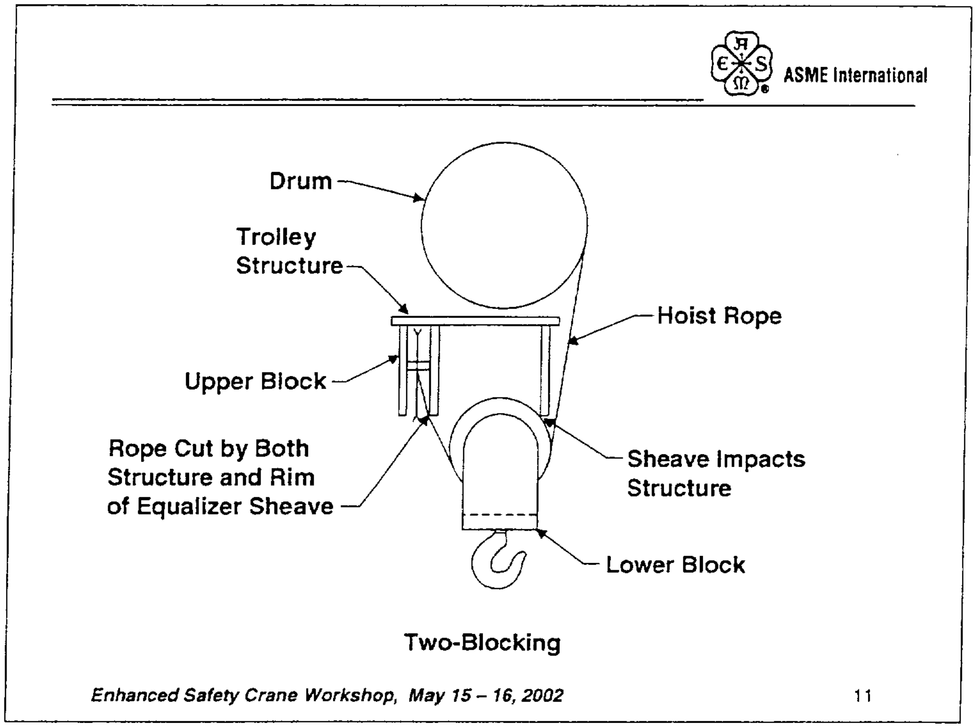
About 20% of crane accidents occur due to two-blocking. This is one of the most serious types of crane accidents that can occur. It is also one of the easiest to prevent.

The crane operator is the first defense against two-blocking. The operator should be aware how serious two-blocking is and be very aware of the risk associated with raising the hook near the upper extremes of the hook travel. The crane operator should never rely on the operation of the upper limit switch to prevent two-blocking. The upper limit switch should never be used in a operation as the means to stop the hoist.

When the hook is in the upper limits of travel it is difficult to see how close the hook block is to the upper limit switch (sometimes the hook block is large or sometimes the load itself obstructs visibility). The operator must never rely of questionable visibility when raising the hook block that high.



Enhanced safety cranes provide two upper limit switches to prevent two-blocking. These two switches are actuated by separate means and operate differently within the crane controls. If the first limit switch is encountered by the hook block the controls stop the hoisting motion but it allows the hook to be lowered using normal crane controls. If the second limit switch is encountered, the second limit switch is designed to turn off all crane power so as to indicate failure of the first limit switch. Limit switch repair will be required.

Common Crane Accidents

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- Two Blocking (continued)
  - The electric motor can produce high torque in a fraction of a second.
    - A DC motor can produce 180% of rated motor torque.
    - An AC motor can produce 275% of rated motor torque.
    - we are assuming the motor is not oversized.
  - During the two block event two things happen at the moment the upper and lower block impact.
    - First the motor torque increases abruptly, secondly the rotational inertia of the hoist motor adds to the motor torque.
  - If the wire rope does not fail something else will. Perhaps damage will be hidden (in say a coupling or gear reducer).
  - Hoist machinery is not designed to withstand the loads created during two blocking.

Hoist motion after limit switch actuation is an important item for consideration here. Rotational inertia of the hoist drive machinery or normal operation of the hoists electrical controls can allow the hook block to travel (or drift) beyond the trip point (or actuation point) of the limit switch. In some hoists the hook drift can be quite large (several inches). Testing of the limit switch(s) must account for this.

Drift for the upper limit switch must be accurately measured and sufficient distance between the trip point and final rest location of the hook block established. Testing must accommodate adequate margins between the final rest location of the hook block and two-blocking. When two upper limit switches are used sufficient distance between the first limit switch and the resting place of the hook block and the trip point of the second upper limit switch must be provided. You would not want the first hoist upper limit to actuate only to have the hook block to drift into the second limit switch (falsely tripping it).

A rigorous inspection and testing program of the hoist upper limit switch(s) is needed.

Common Crane Accidents

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- Play the Two Block film clip.

This video shows how quick the two block occurs. The rope failure and the load block falling occurs in less than a second, much faster than a crane operator can react. It points out the power that can be generated by the hoist motor and the additive effect of the rotational inertia from the drive machinery.

This is an instructional video from Ederer, Incorporated (it is used with their permission).

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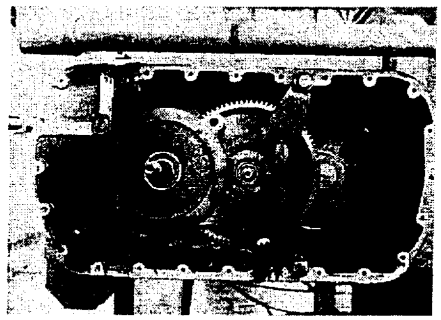

Gear Box Depicting the Spider Plate and Relative Position of the Spider in the Gear Box

This is a photograph of the interior of a hoist gearbox from a 40-Ton electric overhead crane. This hoist had been two-blocked.

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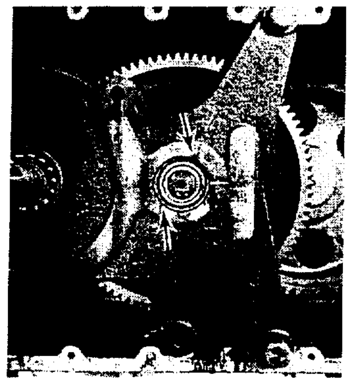

Cracks Around the Shaft and Bearing

Cracks can be seen on the "gear spider" (this is the internal structural element that supports the center gear). This damage was caused when the crane was two blocked (the upper limit switch on the crane failed).

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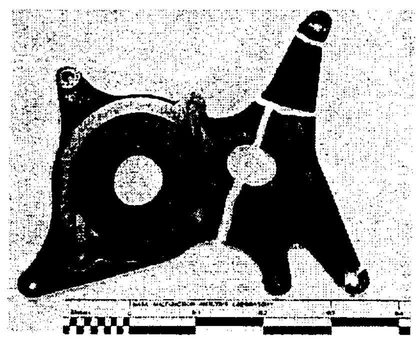

Spider Plate Removed From the Gear Box

Note, the damage was not apparent after the two blocking incident. The crane worked without problem for about three years before the damage was discovered.

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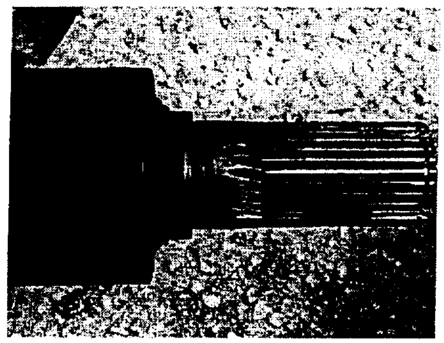

Drum Shaft Spline Depicting the Deformation Found After the Spider Failure

This is a splined shaft from the same 40-Ton Crane. Note, the twisting of the shaft. Again this damage was not discovered until three years after the two block incident.

Common Crane Accidents

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- Load Hang-up
  - Load hang-up is entanglement or snagging of the load. Or other abrupt prevention of further motion of the hoist, trolley or bridge after the load has begun moving. The closer the motor is to full speed, the more severe the effects of the hang-up will be.

About 13% of crane accidents occur due to load hang-up.

Like the over capacity lift, the overload limit devices cannot protect the hoisting equipment from load hang-up accidents. The hoist motor produces overcapacity torque in a fraction of a second. This is too quick for the overload limit device to operate.

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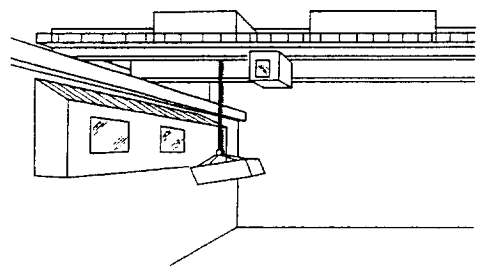

Load Hang-up

Load hang-up can be as shown where a load contacts and hangs up in structure. Also, a load hang-up can occur where a load is bolted (or partially bolted) to structure such as the floor or to its support structure. Also, say the object is bolted to a trailer or railcar.

Common Crane Accidents

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- Load Hang-up (continued)
- Load hang-up has the same effect on the hoist machinery as two blocking.
  - However, the elasticity of the wire rope can make the load hang-up less severe, but just as dangerous.
- Neither the hoist machinery, or the wire rope is designed to withstand this type of accident.
- The crane operator is the first line of defense here. Starting all hoist motions slowly is always good practice.

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Good operation practice is to start the hoist motion slowly. Allow the load to just clear the ground by an inch or two. Then stop. Walk around the load make sure that it is completely clear of the ground. Make sure the hoist brakes are properly holding the load (make sure the load does not drift or slowly lower to the ground during a brief hold period).

Common Crane Accidents

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- Mis-spooling
  - Mis-spooling means the wire rope leaves its machined groove on the rope drum, crossing over the groove "ridges" and piling up over other wraps of rope.
    - This can result in severe damage or rope failure, especially if the rope is crushed between the drum and its supporting structure.

Mis-spooling is one of the major causes of wire rope failure. Wire rope failure accounts for 33% of all crane accidents.

The first paragraph of NOG-5411.4, is as follows:

NOG-5411.4 Grooves (Type I Cranes). *Drum grooves shall be machined to a minimum depth equal to three-eighths of the diameter of the hoist rope, and a pitch equal to 1.14 x rope diameter or rope diameter + 1/8 inches, whichever is smaller. The groove radius shall be 1/32 inches larger than the radius of the rope.*

Note, drum groove "pitch" is the center-to-center distance between adjacent rope centerlines on the drum. For Type II and III Cranes the minimum depth of three-eights of the diameter of the rope is "recommended" but not "required."

The text of **NUM-III-7942.2(e) and (f)** is as follows:

(e) Minimum drum groove depth shall be 0.5 times the rope diameter.

(f) The minimum drum groove pitch diameter is either 1.14 times the rope diameter or the rope diameter plus 1/8 inches, whichever is smaller.

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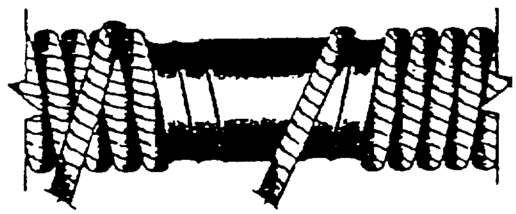

Figure 3—Mis-spooled Wire Rope

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The text of NOG-5426.1 is as follows:

NOG-5426.1 Type I Cranes. *The operating fleet angle A from the drum to the lead sheave shall not exceed 3½ degrees at the one point during hoisting, except in seldom reached positions where it shall be limited to 4½ degrees. The fleet angles B between the upper sheave and the respective reeved lower sheave shall not exceed 3½ degrees.* (Refer to Figure NOG-5426-1 Fleet Angles)

The text of **NUM-I-7942(c) and (d)** is as follows:

(c) In lieu of NUM-III-7942(g), rope fleet angles for the drum shall be limited to 3½ degrees, except that for the last three feet of maximum lift elevation it shall be limited to 4 ½ degrees. See figure NUM-I-7942-2 for fleet angle measurement to the sheaves.

(d) In Lieu of NUM-III-7942(h), rope fleet angles for sheaves shall be limited to 3½ degrees. See figure NUM-I-7942-1 for fleet angle measurement to the drum.

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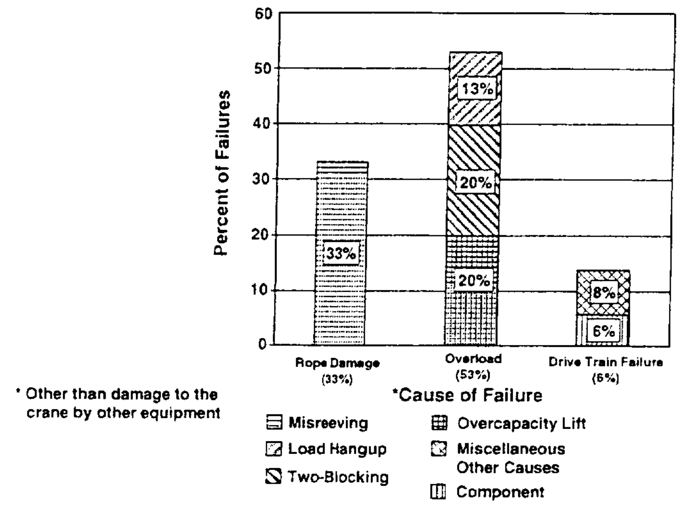

Causes of Load Drops

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Chart is reproduced from Jim Nelson's ICONE-8 paper (it is used with his permission).

Note, the chart shows rope damage accounts for 33% of all crane accidents. The wire rope spool monitor can protect against this. By contrast drive component failure only accounts for 6% of the crane failures. The emergency brake on the drum or the redundant load paths and the like (huge first cost and maintenance expense) provides for protection against (only) 6% of crane accidents.

The single-failure-proof philosophy does not care about the likelihood of failures. It only cares whether the failure is "credible" or not. If there is a "credible" failure scenario, them the cause needs to be mitigated.

Common Crane Accidents

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- We will review each type of crane accident and discuss how the application of NOG-1 and NUM-1 is used to address these common crane accidents.

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ASME Nuclear Crane Standards

ASME NOG-1-1998 & ASME NUM-1-2000

ASME Nuclear Crane Standards

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- History and Background
  - In 1976 the United States Nuclear Regulatory Commission issues for comment a Regulatory Guide providing guidelines for the design of enhanced safety cranes.
  - In response to this ASME was petitioned by industry representatives to sponsor the development of a consensus standard for cranes for nuclear power plants.
  - ASME NOG-1 was first published in 1983 to meet these regulatory guidelines, for top running cranes. It provides enhanced safety features for design, quality assurance and testing.
  - ASME NUM-1 was first published in 1996, for under running equipment.

For additional background on the history of the development of ASME NOG-1 refer to ICONE-8544, "ASME Nuclear Crane Standards for Enhanced Crane Safety and Increased Profit," by Stephen N. Parkhurst.

ASME Nuclear Crane Standards

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- ASME NOG-1, covers Top Running Equipment and Gantry Cranes.
- The following are examples of Top Running Equipment and Gantry Cranes. (insert slides...)
- ASME NUM-1, covers Under Running Equipment, including underhung bridge cranes with wire rope hoists, monorail systems, jib cranes, traveling wall cranes, hand and electric chain hoists, air operated chain and wire rope hoists.
- The following are examples of Under Running Equipment (insert slides...)
- Refer to ICONE-8544, ASME Nuclear Crane Standards for Enhanced Crane Safety and Increased Profit, by Steve Parkhurst (in your handouts).

The documents cover three types of equipment. High quality commercial equipment, seismic qualified equipment, and single-failure-proof equipment. NUM-1 not only covers Underhung bridge cranes with wire rope hoists but also, monorail systems, jib cranes, traveling wall cranes, hand and electric chain hoists, air operated chain and wire rope hoists.

ASME Nuclear Crane Standards

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- Each document will not be covered separately. The documents are very similar in application and methodology. Instead the documents will be covered I parallel, their differences will be discussed.

ASME NOG-1-1998

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- ASME NOG-1 covers three "Types" of equipment. The "Types" provide targeted safety features where needed.
- "Type III" equipment includes high quality commercially manufactured equipment (not single-failure-proof).
- "Type II" equipment covers seismic design requirements for cranes, used in earthquake prone areas (not single-failure-proof).
- "Type I" equipment covers "single-failure-proof" crane designs. This equipment must also remain in place and support a critical load during and after a seismic event.

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Text excerpted from Section NOG-1000, definitions for Type I, II, and III cranes.

crane Type I: a crane that is used to handle a critical load. It shall be designed and constructed so that it will remain in place and support the critical load during and after a seismic event, but does not have to be operational after this event. Single-failure-proof features shall be included so that any credible failure of a single component will not result in the loss of capability to stop and hold the critical load.

crane, Type II: a crane this is not used to handle a critical load. It shall be designed and constructed so that it will remain in place with or without a load during a seismic event; however, the crane need not support the load nor be operational during and after such an event. Single-failure-proof features are not required.

crane, Type III: a crane that is not used to handle a critical load; no seismic considerations are necessary, and no single-failure-proof features are required.

Text excerpted from Section NUM-G-G000, definitions for Type I, IA, IB, II, and III equipment.

Type I equipment: a crane, monorail, or hoist that is used to handle a critical load. It shall be designed and constructed so that it will remain in place and support the critical load during and after a seismic event, but does not have to be operational after this event. Type I equipment shall be designed with either single-failure-proof features (Type IA) or enhanced safety features (Type IB).

Type IA equipment: A Type I crane, monorail, or hoist that includes single-failure-proof features so that any credible failure of a single component will not result in the loss of capability to stop and hold the critical load.

Type IB equipment: A Type I crane, monorail, or hoist with enhanced safety features, including increased design factors and redundant components that minimize the potential for failure that would result in the loss of capability to stop and hold the critical load.

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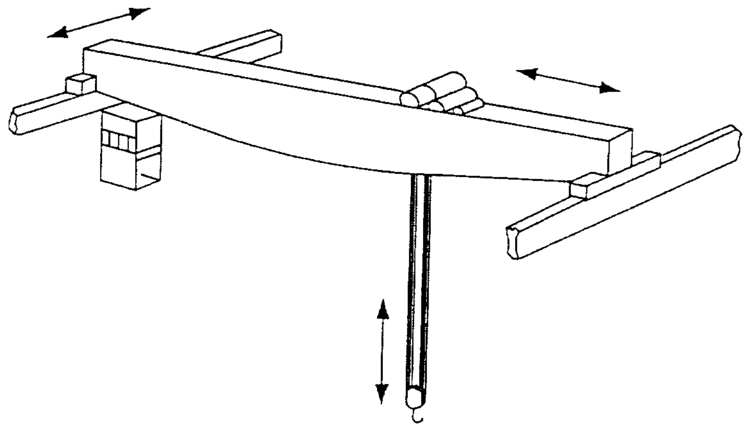
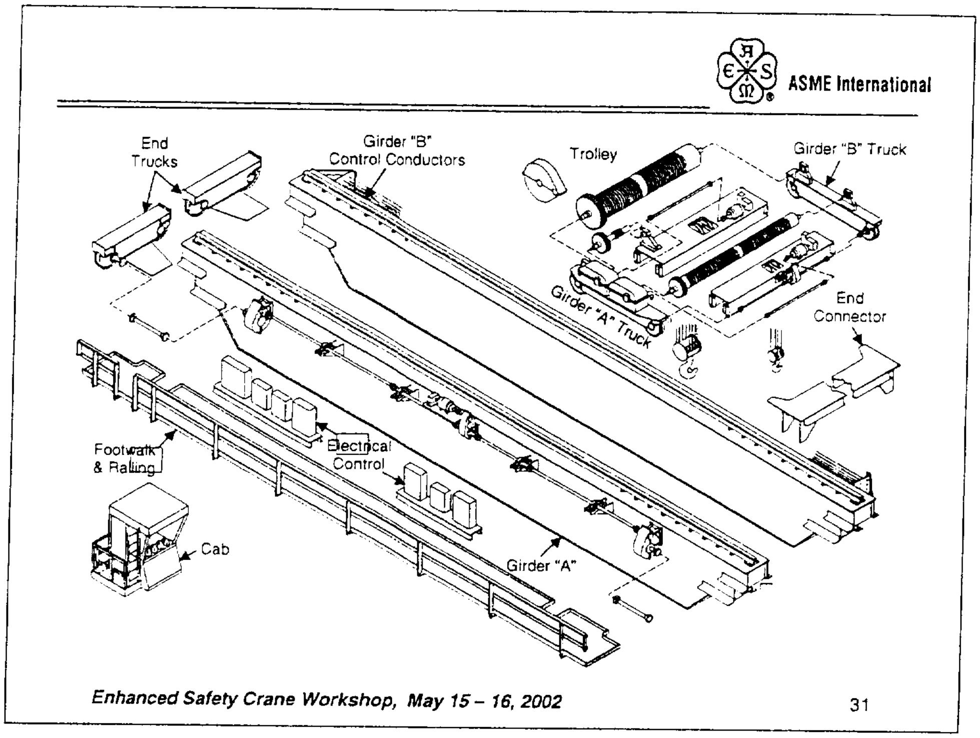


Fig. 3 Overhead crane



This figure shows basic overhead bridge crane components with its name. This is provide for our reference.

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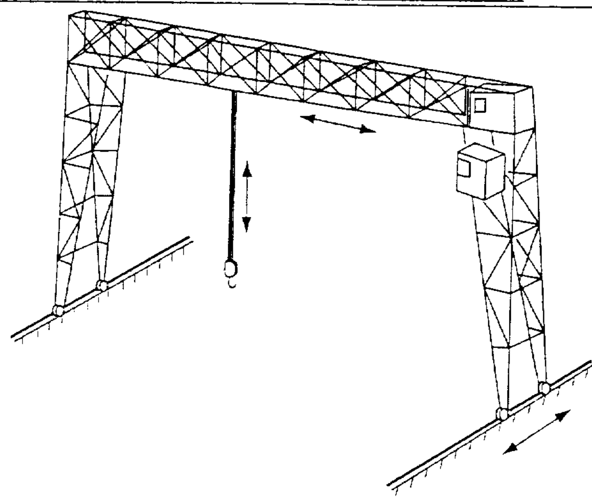

Fig. 2 Gantry Crane

ASME NUM-1-2000

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- ASME NUM-1 covers four "Types" of equipment. The "Types" provide targeted safety features where needed.
- "Type III" and "Type II" equipment requirements are provided like provided in NOG-1.
- However, ASME NUM-1 provides for "Type IA" and "Type IB" equipment.
- "Type IA" equipment is designed using single-failure-proof features similar to NOG-1 "Type I" equipment.
- "Type IB" equipment is designed for enhanced safety features, including increased design factors and redundant (secondary) components to minimize the potential for crane failure.

ASME NUM-I-2000 can be considered a sister document to ASME NOG-1-1998. It also covers under running (overhead) cranes of many types. The under running equipment is usually smaller than the top running equipment (covered in NOG-1).

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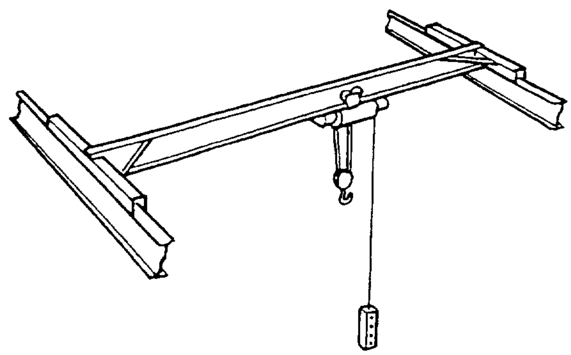

Fig. NUM-III-3100-1 Single-Girder Top-Running Crane

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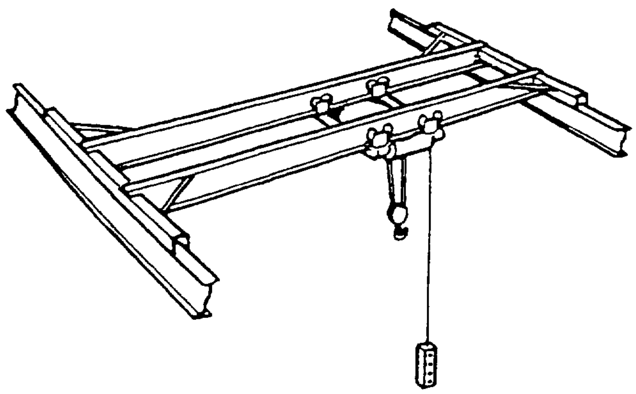

Fig. NUM-III-3100-2 Double-Girder Top-Running Crane With Underhung Trolley

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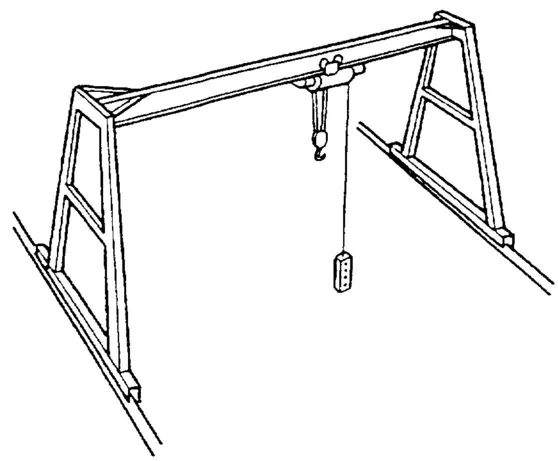

Fig. NUM-III-3100-4 Single-Girder Top-Running Gantry Crane

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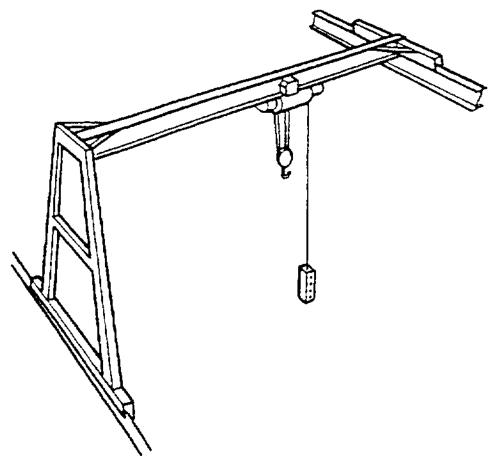

Fig. NUM-III-3100-3 Single-Girder Top-Running Semi-Gantry Crane

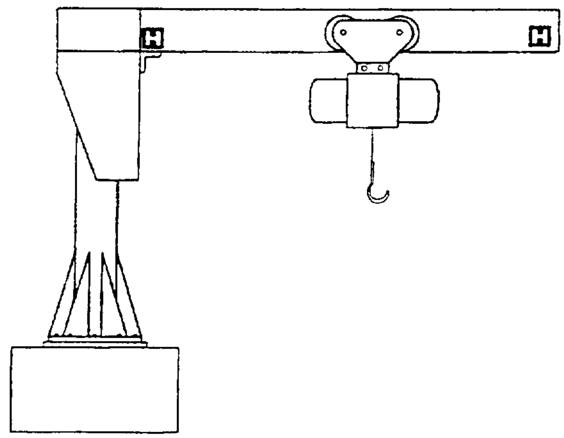

Fig. NUM-III-5100-2 Base-Mounted Free-Standing Pillar Jib Crane

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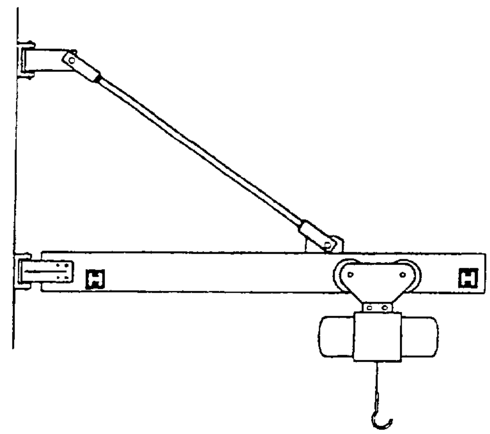

Fig. NUM-III-5100-1 Top-Braced Wall-Mounted Jib Crane

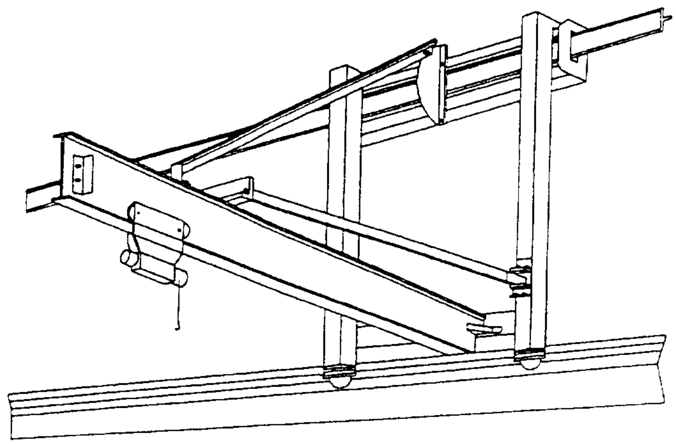

Fig. NUM-III-4100-1(a) Traveling Wall Crane

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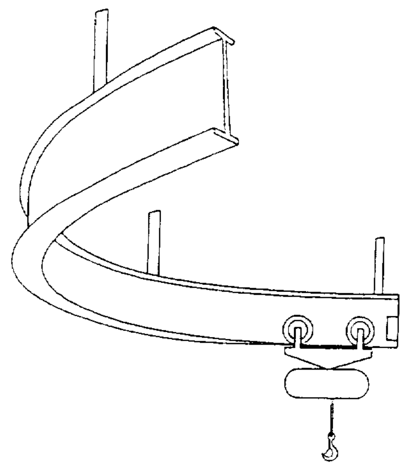

Fig. NUM-III-6100-1 Monorail System

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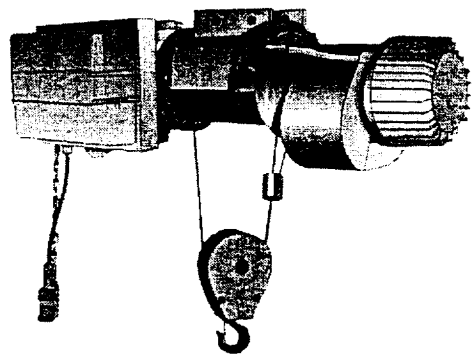


Fig. NUM-III-7100-1 Electric Wire Rope Hoist

ASME International

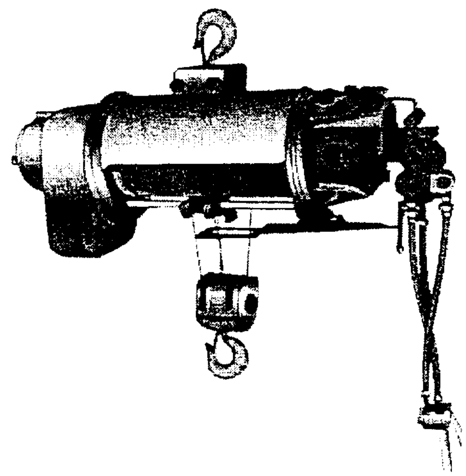


Fig. NUM-III-7100-4 Air-Operated Wire-Rope Hoist

ASME International

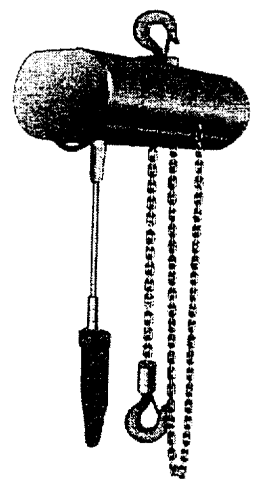


Fig. NUM-III-7100-3 Electric-Chain Hoist

ASME International

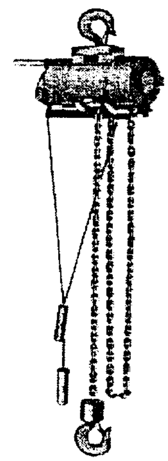


Fig. NUM-III-7100-5 Air-Operated Chain Hoist

ASME International

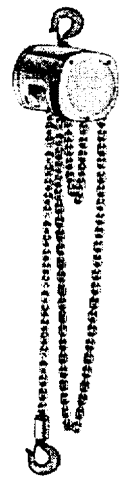


Fig. NUM-III-7100-2 Hand-Chain Hoist

ASME International

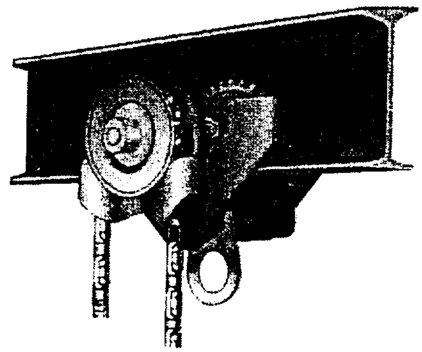


Fig. NUM-III-7100-6 Under-Running Trolley

ASME International

Organization of NOG-1 & NUM-1

Organization of NOG-1 and NUM-1

ASME International

- The two documents are very similar, they cover different types of equipment.
- Will not cover each document separately.
- The documents will be covered in parallel.
- Differences will be discussed.

Organization of NOG-1 and NUM-1

ASME International

- Organization of the NOG-1 and NUM-1 are different.
  - NOG-1 has 9 separate sections. Each section covers Type I, II, and III requirements. Distinctions between Type I, II and III requirements (if any) are noted in each paragraph.
  - NUM-1 is split into 4 major sections:
    - NUM-G General specifications, applicable to all equipment.
    - NUM-I: Type I equipment, this section must be used in conjunction with sections NUM-G, NUM-II and NUM-III.
    - NUM-II: Type II equipment, this section must be used in conjunction with sections NUM-G and NUM-III.
    - NUM-III: Type III equipment, this section must be used in conjunction with section NUM-G.

Text excerpted from NUM-I-1100 as follows:

NUM-I-1100 General

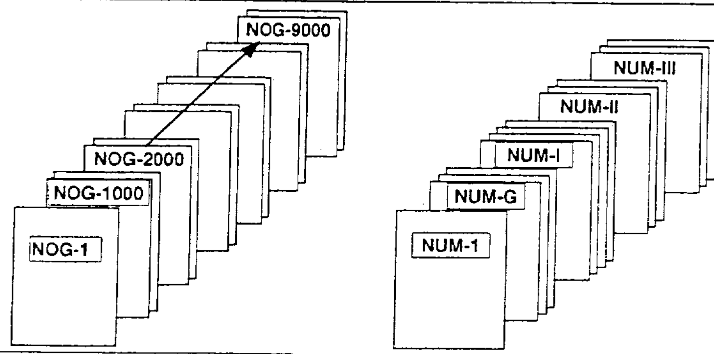
This section of the Standard covers Type I equipment and must be used in conjunction with NUM-G, NUM-II and NUM-III. All NUM-1 paragraphs are either new requirements in addition to NUM-II and NUM-III requirements or supersede existing NUM-II or NUM-III requirements. If NUM-I requirements superseded the NUM-II or NUM-III requirements, the NUM-I paragraph will state which paragraph is supercedes.

...

Requirements designated for Type IA equipment apply only to Type IA; requirement designated for Type IB equipment apply only to Type IB; all other requirements apply to both Types IA and IB. Table NUM-I-1100-1 provides a summary of the major design differences between Types IA and IB.

...

ASME International



NOG-1 has 9 sections. Each section covers requirements for Type I, II, and III cranes. Distinctions between requirements for Type I, II, and III equipment (if any) are noted in each paragraph.

NUM-1 is split into 4 major sections.
For Type I equipment requirements, use NUM-I section in conjunction with NUM-G, NUM-II, and NUM III.
For Type II equipment requirements, use NUM-II section in conjunction with NUM-G and NUM-III.
For Type III equipment requirements, use NUM-III section and NUM-G.

ASME International

Establishing a Crane as Critical or Non-Critical

Critical or Non-Critical Crane?

ASME International

- When is a crane or lifting equipment determined critical (Type I)?
  - Need to determine the effect of a dropped load. If the effect is unacceptable where it may:
    - Jeopardize the public
      - Can it cause the damage of safety critical equipment (jeopardize the ability of the plant to safely shut down)
    - The life safety of people in your facility
    - Damage to high dollar, one-of-a-kind items
- This is a definition you must be comfortable with. It needs to comply with your regulatory authority.
- The application of the "critical" verses "non-critical" design criteria for cranes should be completed carefully and rigorously in your plant.

Critical or Non-Critical Crane?

ASME International

- Is a dropped load all that is of concern?
- Can a handling incident cause the same concern as the dropped load?
- Can the uncontrolled movement of the load, say a few inches, cause a safety concern?
- If the answer is yes, then you need to consider using mechanical hoist arrangements, reeving arrangements, and electrical controls to minimize load movement during a (non load drop) handling incident. We will discuss this more in the Mechanical and Electrical Design sections to follow.

Note, the hoist arrangements shown in Figures NOG-5416.1-1 and NUM-I-7930-2 (hoist configurations provided with a drum brake) must have load movement for the over speed to detect an over speed. The load must accelerate form (say) a stopped condition to the over speed condition of approximately 115% rated speed (this takes a finite amount of time and load must move a distance to accelerate the hoist machinery). Additionally, the over speed switch contacts must open, the air or hydraulic fluid must bleed out of the drum brake and the brake must physically spring set. Finally, the drum brake friction material must contact its mating drum surface and decelerate the load to a stop. Each step takes a finite amount of time. The total load movement may be as little as 6 inches when you have full load on the crane, or it could be more if the load on the hook is less. The dynamic behavior of each hoist will be different. The rotational moment of inertia of the hoist motor and the other components is different for each hoist and the weight of the load will also determine how fast the load accelerates and how fast the load actually stops.

The drum brake is can provide proper proper single failure protection in many cases. Other hoist arrangements may be required if load motion described here is unacceptable to the user.

ASME International

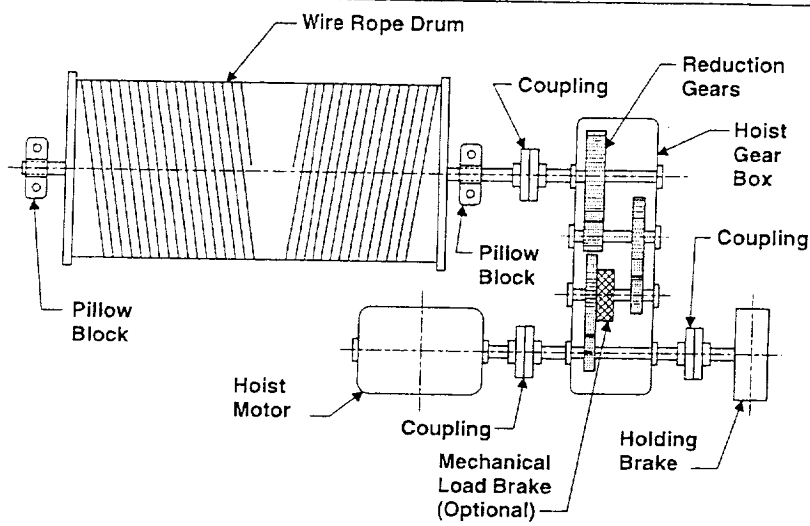
Single-Failure-Proof Concept

Single-Failure-Proof Concept

ASME International

- First, lets discuss a standard electric hoist.
  - The hook is supported by a reeving system using a single wire rope.
  - The wire rope is wrapped around a wire rope drum.
  - The drum is driven by a low speed output shaft from a gear box (couplings are usually provided between the drum shaft and the gear box shaft).
  - The high speed shaft of the gear reducer is coupled to both the electric motor and holding brake.
- The single-failure-proof concept asks what happens when a single component fails. Will this single component failure cause the load to fall?
  - Understand we concern ourselves with "credible" component failure, some components we overlook as "not credible."

ASME International



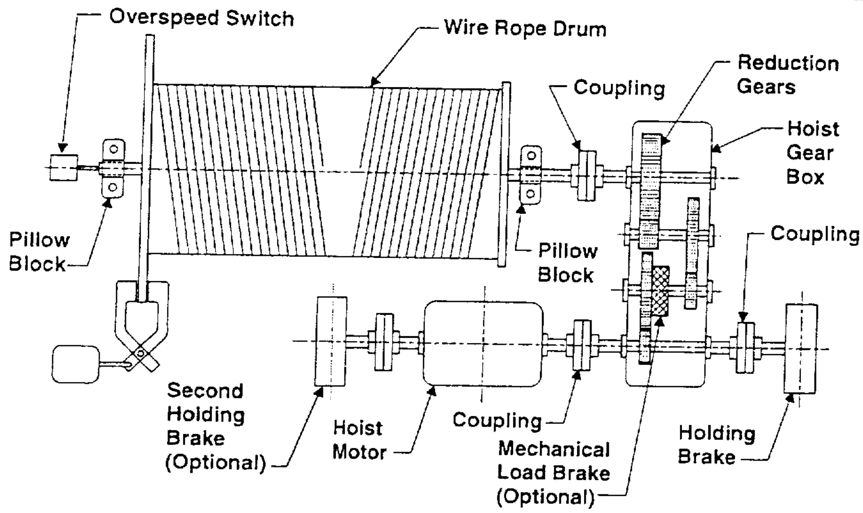
Standard Hoist Mechanical Arrangement

Single-Failure-Proof Concept

ASME International

- Lets look at the standard hoist to see how many single components can fail that would result will be to drop the load.
  - Wire rope
  - Sheave pins
  - Couplings along the load path
  - Shafting
  - Gearing
  - Electric motor
  - Holding brake
- We are going to "rule out" the wire rope drum. This is a heavy structural element, if it is designed and built correctly it will not fail.
- Likewise, structural components like the trolley load girt, and bridge girders will be "ruled out."

ASME International



Single-Failure-Proof Hoist Mechanical Arrangement

Single-Failure-Proof Concept

ASME International

- The Single-Failure-Proof hoist adds a brake directly to the wire rope drum. An over speed switch is added to the hoist drum and is placed in the control circuit to actuate upon drum over speed of 115% (NOG-1) or 120% (NUM-1) of rated speed. The setting of the over speed switch rate depends on the type of motor controls, and the dynamics of the hoist machinery.
- This eliminates all the single-failure-points described earlier.
- A few comments about testing the drum brake:
  - A crane start-up the drum brake must be tested to assure it will work correctly. This must include:
    - Static test of the brake (assure braking torque is produced)
    - Dynamic test of the brake under a load (this can be full or partial load as long as full drum torque is used). Testing must assure the over speed switch trips at the correct setting the brake sets to stop the load within "acceptable" load drift.

Single-Failure-Proof Concept

ASME International

- Comments on in-service inspection and testing: the drum brake may or may not be used during normal crane operation. Any unused brake may degrade in performance over time.
  - Periodic burnishing of the brake friction material must be required.
  - The over speed switch setting is adjustable and must be periodically tested to assure the setting has not drifted outside an acceptable range.
  - Static testing of the brake must be required to assure it is producing its design holding torque. This may include placing a known torque on the drum (perhaps through the gear reducer, using a torque wrench).

Single-Failure-Proof Concept

ASME International

- The single-failure-proof concept can be applied to the bridge and trolley drives. If the bridge or trolley drive fails, does it coast to a safe stop, or does it do something that is not safe?
- Electrical controls can be examined the same way. What is the effect of a single component failure? What happens, when for example, a relay does not change state when it needs too?
  - NOG-1 and NUM-1 requires the use of an emergency stop button for Type I equipment such that if a control failure occurs the emergency stop button can be depressed and the crane will stop (in a safe state). The emergency stop button must be independently wired to the crane power feed. Any control failure can occur and the independently wired stop button will stop the crane. This will place everything on the crane into an un-powered safe condition.

Single-Failure-Proof Concept

ASME International

- A few questions:
  - Can the crane operator perceive all crane failures?
  - If the crane operator can perceive the failure can the operator react to the failure (press the emergency stop button) before unacceptable load motion occurs?

ASME International

Application of NOG-1 and NUM-1

Application NOG-1 and NUM-1

ASME International

- NOG-1, Type I Crane, (single-failure-proof design)
  - Single-failure-proof hoist arrangement
    - Single hoist drive (Figure NOG-5416.1-1) or,
    - Dual hoist drive (Figures NOG-5416.1-2, or NOG-5416.1-3)
    - Reeving is single-failure-proof (Figure NOG-5420-1), reeving must maintain vertical alignment with one rope intact (10:1 design factor on wire rope breaking strength).
    - Gearing is designed for strength and durability with appropriate design factors.
    - Components in the hoist load path are designed with appropriate design factors for and shall account for seismic loads and "emergency conditions" such as load hang-up. Allowable stress equal to 75% of the yield strength (refer to NOG-5321.2).

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NOG-5321.2 Emergency Conditions. For all emergency loads such as load hang-up, seismic loads, using the gross cross section excluding the stress concentration factors, the service factors shall be not less than 1 based on allowable stress equal to 75% of the yield strength, unless specifically exempted elsewhere in NOG-5000.

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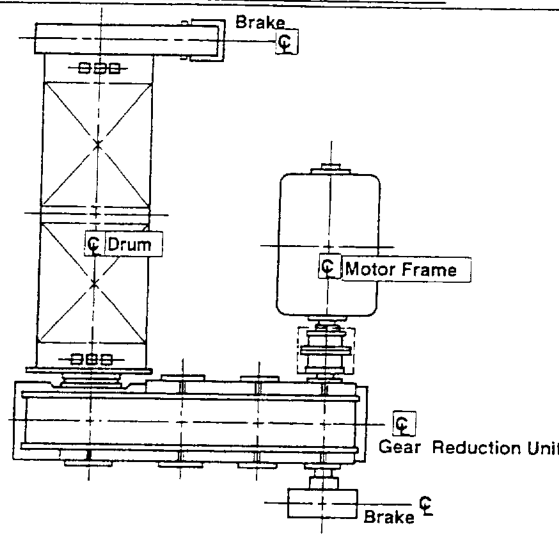


Fig. NOG-5416.1-1 Typical Single-Hoist Drive Unit

ASME International

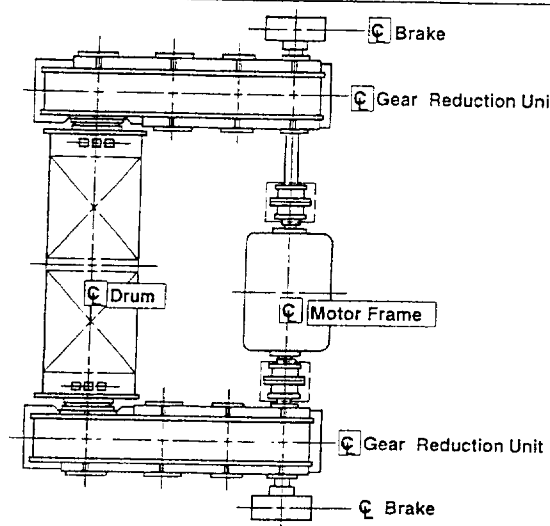


Fig. NOG-5416.1-2 Typical Dual-Hoist Drive Unit

ASME International

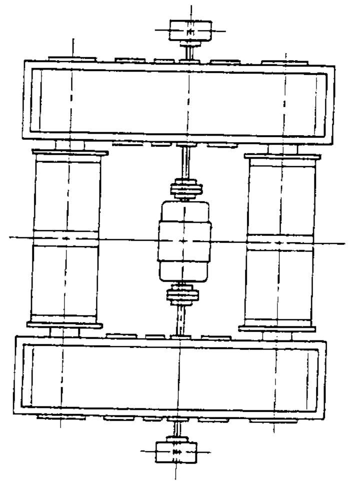
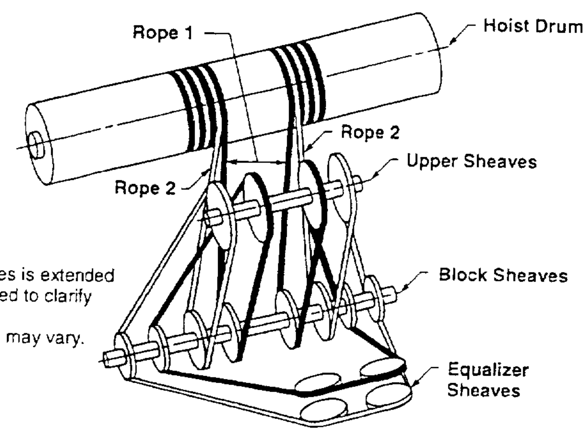


Fig. NOG-5416.1-3 Typical Dual-Hoist Drive Unit

ASME International



NOTES:
(1) Relative position of sheaves is extended and angle of view is distorted to clarify reeving paths.
(2) Number of parts of reeving may vary.

Fig. NOG-5420-1 Single Failure-Proof Reeving Example

Application NOG-1 and NUM-1

ASME International

- Differences between NUM-1, Type IA and IB equipment: Refer to Table NUM-I-1100-1
  - Type IA equipment requirements provides single-failure-proof hoist arrangements (two load paths through gearing shafts and couplings, and two holding brakes).
  - Type IA equipment allows for custom designed equipment (Figure NUM-I-7930-1 and NUM-7930-2).
  - Type IA equipment allows for two commercially manufactured hoists arranged into a "dual drum" configuration (Figure NUM-I-7930-3).
  - Reeving arrangements required for single and dual drum hoist configurations are found in Figure NUM-I-7942.3-1, Figure NUM-I-7942.3-2 and Figure NUM-I-7942.3-3.
  - Equalizer system designed to withstand the load transfer from two ropes to one.

Text excerpted from NUM-I-7930 as follows:

(b) (Type IA) The hoisting machinery from the motor to the drum shall be designed to provide assurance that a failure of a single component would not result in the uncontrolled movement of the lifted load. The wire rope drum shell is exempted from this requirement.

(c) (Type IA) Load motion due to failure of one load path of a redundant load path hoist shall be evaluated as to facility acceptability.

(d) (Type IA) Figurers NUM-I-7930-1, NUM-I-7930-2, and NUM-I-7930-3 provide some block diagrams illustrating examples of Type IA hoist equipment configurations. These block diagrams are not meant to show actual configurations and may be rearranged as needed to meet the specific application. These diagrams are only a few of many acceptable configurations.

ASME International

GENERAL NOTE: This figure is a block diagram provided to show conceptual layouts only. The machinery together with the reeving arrangement must comply with the vertical alignment requirements in NUM-I-7942.3(b).

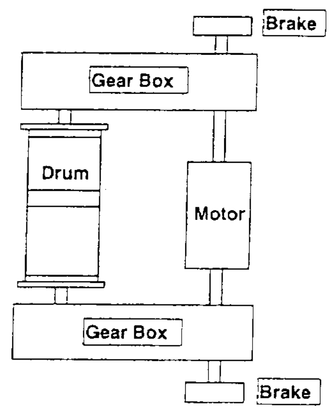


Fig. NUM-I-7930-1 Type IA Dual Hoist Drive Unit With Single Drum

Text from NUM-I-7942.3, NUM-I-7942.4, and NUM-I-7942.5 as follows:

NUM-I-7942.3 Reeving

(a) (Type IB) The reeving system may have a single load path design, utilizing either a single or double reeving arrangement. See NUM-III-7942.3-1 for examples.

(b) (Type IA) The reeving system shall be divided into two separate (redundant) load paths so that either path will support the load and maintain vertical alignment in the event of rope breakage or failure in the rope system. See Figurers NUM-I-7942.3-1, NUM-I-7942.3-2, and NUM-I-7942.3-3 for examples of Type IA reeving systems. These figurers show three of many acceptable configurations.

NUM-I-7942.4 Equalizer Systems (Type IA).

Equalizer systems shall be able to withstand the dynamic forces from load transfer upon failure of one wire rope and shall not load the remaining intact reeving system more than 40% of the breaking strength of the wire rope.

NUM-I-7942.5 Equalizer Systems (Type IB).

The equalizer for a Type IB reeving system, when provided, may be a sheave or a bar, and shall be designed for twice the rated load.

ASME International

GENERAL NOTE: This figure is a block diagram provided to show conceptual layouts only. The machinery together with the reeving arrangement must comply with the vertical alignment requirements in NUM-I-7942.3(b).

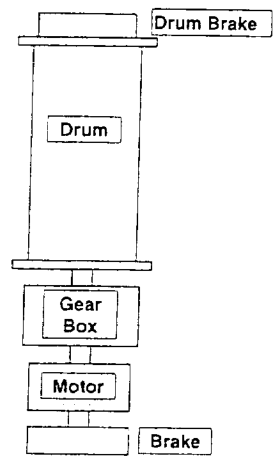


Fig. NUM-I-7930-2 Type IA Single Hoist Drive Unit With Drum Brake

ASME International

GENERAL NOTE: This figure is a block diagram provided to show conceptual layouts only. The machinery together with the reeving arrangement must comply with the vertical alignment requirements in NUM-I-7942.3(b).

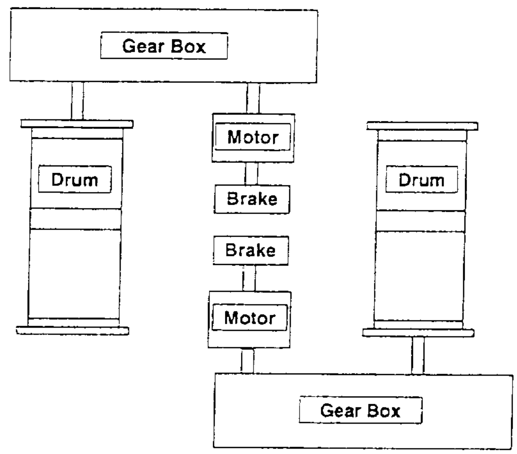


Fig. NUM-I-7930-3 Type IA Dual Hoist Drive Unit With Dual Drum

ASME International

GENERAL NOTE: Relative position of sheaves is extended and angle of view is distorted to clarify reeving paths. An equalizer system between the two ropes is required but is not shown for clarity. The machinery together with the reeving arrangement must comply with the vertical alignment requirements in NUM-I-7942.3(b).

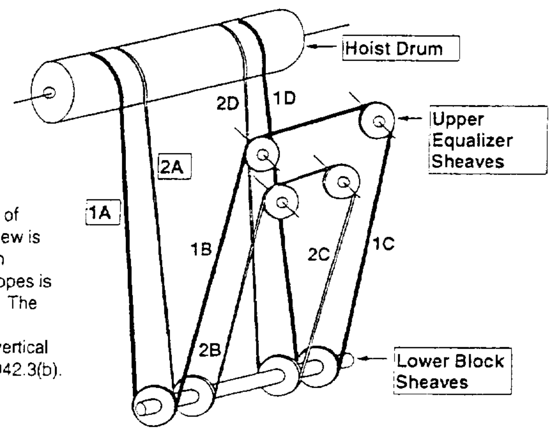
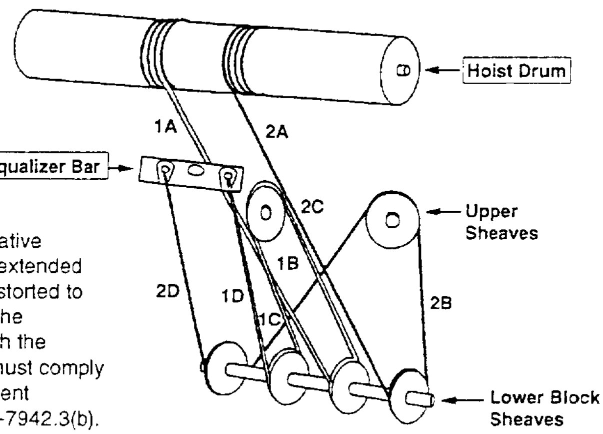


Fig. NUM-I-7942.3-1 Type IA Redundant Reeving With Single Drum

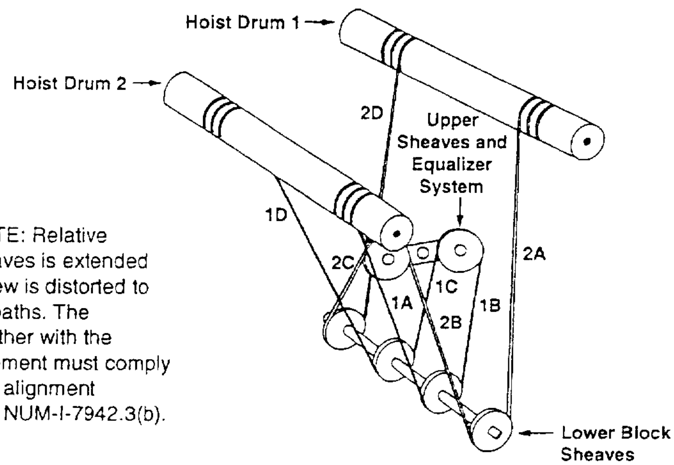
ASME International



GENERAL NOTE: Relative position of sheaves is extended and angle of view is distorted to clarify reeving paths. The machinery together with the reeving arrangement must comply with the vertical alignment requirements in NUM-I-7942.3(b).

Fig. NUM-I-7942.3-2 Type IA Redundant Reeving With Single Drum

ASME International



GENERAL NOTE: Relative position of sheaves is extended and angle of view is distorted to clarify reeving paths. The machinery together with the reeving arrangement must comply with the vertical alignment requirements in NUM-I-7942.3(b).

Fig. NUM-I-7942.3-3 Type IA Redundant Reeving With Dual Drum

Application NOG-1 and NUM-1

ASME International

- Differences between NUM-1, Type IA and IB equipment: Refer to Table NUM-I-1100-1 (continued)
  - Type IB equipment requirements allows for a single commercially manufactured hoist.
    - The drum shaft and bearings, equalizer system (sheave or bar), and motor shafts shall be designed for twice the rated load.
    - The reeving system may have a single load path, utilizing either a single or double reeving arrangement. Wire Rope shall have a 10:1 design factor.
    - Gearing designed for strength and durability ratings shall be based on twice the torque required to lift the rated load.
    - Brakes for the hoist shall have two holding brakes and a control braking means.

ASME International

Table NUM-I-1100-1 Major Design Differences Between Type IA and IB

Item	TYPE IA Single-Failure-Proof Features (Design Factors Based on Ultimate Strength)	TYPE IB Enhanced Safety Features (Design Factors Based on Ultimate Strength)	Reference Section
Reeving	Dual Load Path Design (Redundant Reeving)	Single Load Path Design (Single or Double Reeving)	NUM-I-7942.3
Drum Bearings/ Shaft	5:1 With Drum Restraint	5:1 With Drum Restraint or 10:1 Without Drum Restraint	NUM-I-7942.2
Gear Box	Redundant or a Brake on the Rope Drum	Twice the Torque Rating of the Gears	NUM-I-7945

Application NOG-1 and NUM-1

ASME International

- NOG-1 and NUM-1 Type II Cranes (seismic qualified equipment)
  - The Type II equipment must stay in place in the event of a Safe Shutdown Earthquake.
    - Safe Shutdown Earthquake - site specific parameters for use in seismic analysis of the crane or monorail.
    - Maximum Seismic Lifted Load - the maximum lifted load for a Safe Shutdown Earthquake. This loading condition is the maximum lifted load under the evaluated seismic conditions where the crane trolley or hoist must stay in place.

Application NOG-1 and NUM-1

ASME International

- NOG-1 and NUM-1 Type II Cranes (continued)
  - Additional analysis is necessary to assure crane components such as mechanical parts, electrical control panels and the like will not dislodge from the crane and damage "safety related" equipment during the seismic event.
  - NOG-1 and NUM-1 describes design methodology used to complete this analysis.
  - Also, inspection testing and quality control is covered.

Application NOG-1 and NUM-1

ASME International

- NOG-1 and NUM-1 Type III Equipment (commercially available equipment)
  - When single-failure-proof or seismic qualified equipment is not required commercial equipment is the cost effective means to meeting the user needs.
  - General design criteria is provided for type three equipment. High quality commercial equipment should meet these criteria. Note, the document is quite specific about some items. Many items/parts or design methods are "required" as opposed to "recommended." Both NOG-1 and NUM-1 are strong contractually, the crane builder needs to comply with items that are "required."

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Text excerpted from NUM-I-1100 as follows:

(b) Equipment covered this standard shall be designed in accordance with the Standard's requirements, but not necessary with its recommendations. The word "shall" is used to denote a requirement, the word "should" is used to denote permission, which is neither a requirement nor a recommendation.

NOG-1100 has similar wording.

ASME International

A Closer Look at Design

Quality Assurance

ASME International

- Quality assurance provisions are covered in NOG-1, reference section NOG-7100, and Tables NOG-7200-1, and NOG-7200-2. Also, NUM-1 reference section NUM-I-8500 and Tables NUM-I-8521-1A and NUM-I-8521-1B (these tables are provided in your handout material).
  - This provides the specific test and acceptance criteria for individual components on the crane.
- These tables are very comprehensive and practical.
  - A high degree of testing is required on "critical" parts in the hoist load path. Other less critical parts required less inspection and testing.

Environmental Conditions of Service

ASME International

- Radiation, Temperature, Pressure, Humidity, Chemical, Wind, Seismic.
  - Radiation - specify accumulated radiation dosage to be seen by the crane expected in the life of the facility.
  - Temperature - specify maximum and minimum operating temperatures, ambient temperature for motors, and maximum and minimum construction temperatures.
  - Pressure - specify normal operating pressure, any test or abnormal event of these pressures including rate of change.
  - Humidity - humidity conditions where the crane operates.
  - Chemical - is the crane subject to spray systems? Is the load block and wire rope immersed in pools?
  - Wind and Seismic - operating wind, and design wind (storage), plant tornado wind, seismic parameters.

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Excerpt, NOG-1130 as follows:

NOG-1130 Responsibility

The cranes covered by this Standard are classified into three types (see NOG-1150, Definitions, crane types) depending upon crane location and usage of the crane at a nuclear facility.

The owner shall be responsible for determining and specifying the crane type. The owner shall also be responsible for determining and specifying the environmental conditions of service, performance requirements, type and service level of coatings and finishes, and degree of Quality Assurance.

Determining the extent to which this Standard can be used, either in part or in its entirety, at other than nuclear facilities, shall be the responsibility of those referencing the use of this Standard.

Structural Design

ASME International

- Materials, Fasteners, Fracture Toughness, Girder Design
  - Materials - Reference Table NOG-4211-1 (provided in your handout materials), these are acceptable materials for structural components.
  - Fastener Materials - Reference Table NOG-4221-1 (provided in you handout materials), these are acceptable fastener material for structural connection.
  - Fracture Toughness - base materials for structural components must be impacted tested (specify minimum operating temperature).
  - Girder Design - a somewhat conservative girder design (overall structural design) is provided in NOG-1. NUM-1, provides a more conventional design.

Mechanical Design

ASME International

- Can a handling incident cause the same concern as the dropped load?
- Can the uncontrolled movement of the load, say a few inches, cause a safety concern?
- When these items are considered, review the Type I hoist arrangements carefully. Several Type I arrangements provide differing degrees of protection.
  - For example, consider the Type I arrangements shown in Figurers NOG-5416.1-1 and NUM-I-7930-2 (hoist configurations provided with a drum brake). Upon component failure this hoist arrangement will allow several inches in load movement (perhaps 6 inches or more) before the load actually stops.

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Consider a Type I hoist arrangement where a drum brake is provided. What must happen for the load to stop when a component in the hoist load path fails. When the part fails the load will start falling, rotational inertia and friction in the intact portion of the hoist is the only thing slowing the load. The over speed switch directly measures the rotational speed of the drum, when the drum speed reaches the over speed set point (say 120% of maximum rated speed of the hoist) the contacts in the over speed switch open. The open contacts in the hoist control circuitry opens power to an electrical coil on a valve to an air or hydraulic cylinder holding the drum brake open against the springs that set the drum brake. The drum brake springs apply the drum friction surface. As the drum brake friction material clamps around the drum, friction is produced and the drum decelerates to a stop. Each item described, that is - opening of the speed switch, releasing the air or hydraulic fluid from the brake, allowing the springs to set ,etc. takes a small amount of time. The load continues to move while this is happening. Several inches of load motion will occur. In fact, several inches of load motion will occur before the drum brake sets begins to on the drum. Several more inches my occur before the load actually stops. In any event the amount of load motion that actually occurs is different from hoist to hoist and will change based on what component failed, the load on the hook, amount of rotational inertia in the hoist machinery and other factors. The question I place before you how critical is this load motion? In many cases it is not critical and the drum brake provides adequate protection. Some people may argue that the single-failure-proof philosophy is getting too extreme in its application. The likelihood of the failure occurring at the worst possible time (when the load is in close proximity to say critical equipment) is small compared to the more likely event where the load is safely away from anything critical. In any event, this problem can be solved by using dual load path hoist machinery.

Mechanical Design

ASME International

- Consider the use of the use of a dual hoist drive machinery. Refer to Figures NOG-5416.1-2, NOG-5416.1-3, NUM-I-7930-1 and NUM-I-7930-3.
  - Loss of a single component will not cause a lowering of the load. There is a redundant load path in place to support the load. So as far as load motion upon component failure this system is better.
  - But it does cost more, and it is much larger (hopefully you have the space for it).

Any load movement that results from a single component failure will be caused by the transfer of load from a shared condition between the two load to only one load path. The tensional windup of drive shafts and the deflection of internal gear teeth is the only items that will cause the load to move.

Mechanical Design

ASME International

- Reeving systems, NUM-I, Type IB allows for a "standard reeving" with double the usual design factor on the wire rope.
  - This is a very simple eloquent design (used almost everywhere). There is little that can go wrong, this should be considered very safe. However, if the wire rope were to fail the load would fall, so it violates the single-failure-proof criteria.
  - Lets consider the single-failure-proof reeving systems shown in Figures NOG-5320-1, NUM-I-7942.3-1, NUM-I-7942.3-2 and NUM-7942.3-3. What would happen if a wire rope were to fail?
    - Significant load motion will occur with all systems.
    - Reeving systems shown in Figurers NOG-5320-1 and NUM-I-7942.3-1 will have less load motion.
    - The broken rope will probably fall to the floor. This is a personnel and equipment safety hazard, although less of a hazard than dropping the critical load.

Vertical motion will occur with failure of one wire rope on all single-failure-proof reeving diagrams shown in NOG-1 and NUM-1. The transfer of the load from two wire ropes to the remaining wire rope will cause additional rope stretch in the intact rope causing the vertical load motion.

Horizontal motion will also occur. Horizontal load motion will be more pronounced using reeving systems like shown in Figurers NUM-I-7942.3-2 and NUM-I-7942.3-3. Movement of the equalizer bar in these two arrangements will cause the load to shift and also twist slightly about the vertical axis.

In all cases breaking a wire rope will be very bad. Vertical and horizontal load motion will occur. The broken rope will in most cases will fall to the ground (especially heavy rope). This means the rope will un-reeve with the broken end pulling itself through sheaves, perhaps many times depending on the parts of reeving involved. There is a tremendous safety hazards here, even a small wire rope falling a short distance can injure someone or damage equipment. Granted it is better than dropping the load outright.

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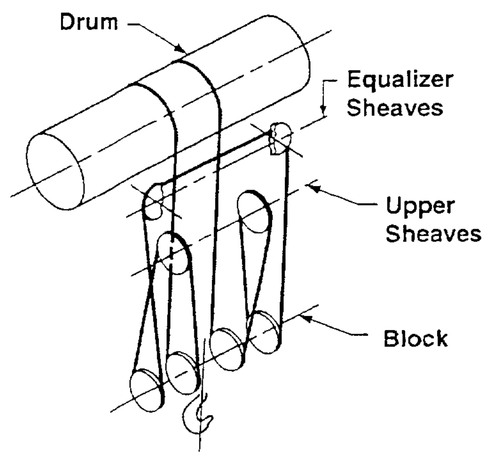

8 Part Reeving

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Reeving System Commentary: With proper wire rope inspection and maintenance the only "credible" way for the wire rope to fail is from external damage. Something must make the wire rope fail. Here, the likelihood that both wires will suffer damage at the same time is great. I wonder if the two rope reeving systems provided that much additional safety.

Another thought, two rope systems that use a dead end to an equalizer bar do not seem to me, to be as safe as a two rope system that uses two equalizer sheaves (or for that matter a single rope system, with standard reeving). The dead end of the rope must be terminated with some sort of an end fitting. Some believe the end fitting itself is a point of failure (this gives the rope a place to fail).

I would recommend a spelter socket or swaged fitting for the dead end of the wire rope. They must be load tested to 150% before use. If you use another type of end fittings on the dead end make sure the appropriate de-rating factor is applied to the end fitting, and reeving system.

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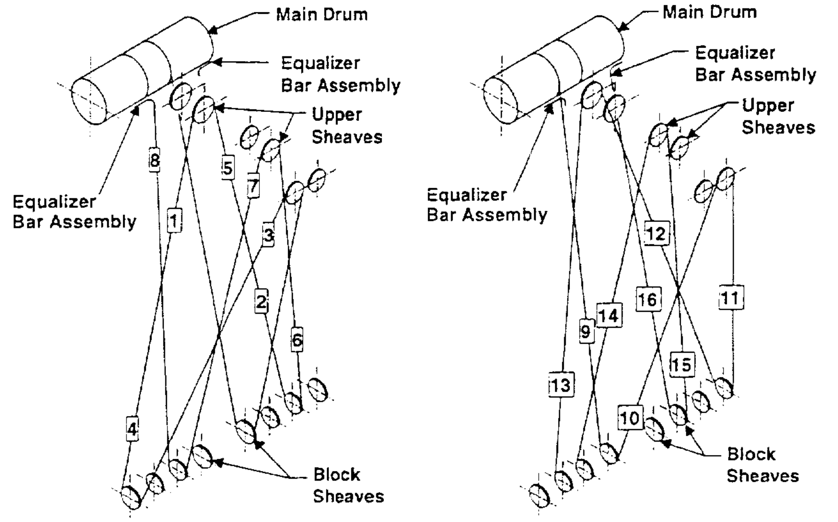

Enhanced Safety Reeving (Whiting Corporation)

Common Crane Accidents

ASME International

- Mis-spooling (continued)
  - To guard against mis-spooling NOG-5411.4 requires a minimum depth for the of the drum grooves. For the smaller NUM-1 equipment (with lighter lower blocks) the drum groove depth is deeper. Refer to NUM-III-7942.2(e) and (f).
  - Also, note the limitation of rope fleet angles ASME NOG-5426.1 and 5426.2 and NUM-I-7942 (c) and (d), and NUM-III-7942(g) and (h).
  - ASME NOG-6446.1 and NUM-I-7947.3 requires a mis-spooling monitor placed on the drum to trip a switch in the control circuitry if the wire rope is displaced from its grooves.
  - ASME NUM-I-7947.5 requires equalizer travel error indication device (for Type IA Equipment).
  - Even with good design the first line of defense against wire rope mis-spooling is the is the alert crane operator.

The text of NUM-III-7942(g) and (h) is as follows:

(g) Rope fleet angles for the drum shall be limited to 4 degrees.

(h) Rope fleet angles for sheaves shall be limited to 4 degrees 45 minutes.

Text of NOG-6446 as follows:

NOG-6446 Hoist Drum Rope Mis-Spooling Limits (Type I Cranes). *Hoists that handle critical loads shall include a hoist drum rope mis-spooling limit switch to detect improper threading of the hoist rope in hoist drum grooves.*

Actuation of this switch shall result in removal of power from the hoist motor and setting of the hoist holding brakes.

Actuation of this limit device shall prevent further hoisting or lowering until a key-operated bypass is used to enable lowering out of the mis-spooled condition, with further hoisting prevented until the mis-spooled condition is corrected. The limit shall be tested for proper operation before making any additional lifts.

Text of NUM-I-7947.3 as follows:

NUM-I-7947.3 Hoist Drum Wire Rope Spooling Monitor. *Hoists shall include a wire rope spooling device to detect improper threading of the hoist rope in the hoist drum grooves. Actuation of this device shall result in removal of power from the hoist motor and setting of hoist holding brakes. Actuation of this limit device shall prevent further hoisting. A mechanical rope guide that encompasses the circumference of the drum and provides spooling of the wire rope onto the drum may be used in lieu of a spooling device.*

Electrical Controls

ASME International

- Motor Controls
  - New section provided for variable frequency AC.
  - Other types of motor controls are also provided.
- Limit Switch Arrangements
  - Hoist limit switch arrangements are specified for two block protection (see NOG-6442 High Limits)
    - Provides two separate switches, First High Limit Switch (control circuit switch).
    - The second switch, Final Over travel High Limit Switch (power circuit type, direct acting).

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Text of NUM-I-7947.5 as follows:

NUM-I-7947.5 Equalizer Travel Error Indication Device (Type IA). *A sensing and signaling means shall be provided to automatically shut down the hoist and provide indication to the operator if displacement between the separate reeving systems exceeds design operating limits.*

Type the text for NOG-6110, 6442, 6432.3, 6442.1, 6442.2, and 6442.3.

NOG-6110 Single Failure Features (Type I Cranes)

(a) The electrical system shall be designed so that it is possible for the operator to stop and hold a critical load regardless of the failure of any single component utilized in normal operation.

(b) There shall be means at the operator's location that will allow him to remove power from all drive motors and brakes by opening or de-energizing a power device that is not required to close and open during normal "run-stop" operations.

(c) Any inadvertent short circuit or ground shall be considered a single component failure.

(d) The avoidance of two-blocking shall be accomplished by the use of single-failure proof features and shall not rely on any action by the operator. The normal hoist limit switch shall be supplemented by an independent final hoist limit switch operated by the load block to remove power from the hoist motor and brakes.

Electrical Controls

ASME International

- Emergency Stop Button, See NOG-6432.3 Motor Power Circuit Disconnecting Device
  - Single-failure-proof features rely on this device (See NOG-6110).
  - Remote emergency stop (not required in NOG-1 or NUM-1).
    - This is a remote emergency stop button is, "remote" from the cranes operators emergency stop button.
    - This can be provided where the crane operator may not have visibility of the entire load (or critical portions of the load or obstructions). A second person can stop all crane operation independently of the crane operator.

The remote emergency stop button is functionally identical to the emergency stop button. It is a secondary motor power circuit disconnecting device.

The remote emergency stop button can be placed on a handheld (sometimes plug-in the wall) pendent with a long cord to enable a person to position himself at load handling level where critical obstructions or additional visibility is needed.

Common Crane Accidents

ASME International

- Two Blocking (continued)
- The best defense against two blocking is prevention. For Type I equipment NOG-1 and NUM-1 requires two upper limit switches.
  - The first switch is a control type, the second switch is a power switch (if the first switch fails, the power switch prevents the two blocking). In-service inspection and testing is used to assure the second switch always works.
- Lets say the upper limit switch fails for some reason, in-service inspection and testing does not find it, or say the inspection found the problem but the repair to be delayed until a later time.
  - The crane should never be operated with non functioning equipment.
- Let's say the crane operator cannot see the position of the hook (very well). So the operator drives the hoist into the limit switch.
  - The limit switches should never be used this way.

Enhanced safety cranes provide two upper limit switches to prevent two-blocking. These two switches are actuated by separate means and operate differently within the crane controls. If the first limit switch is encountered by the hook block the controls stop the hoisting motion but it allows the hook to be lowered using normal crane controls. If the second limit switch is encountered, the second limit switch is designed to turn off all crane power so as to indicate failure of the first limit switch. Limit switch repair will be required.

Planned Engineered Lifts

ASME International

- Sometimes lifts at greater than the cranes rated capacity is needed a few times during the life of the crane.
  - This may be needed for say major equipment replacement within the facility.
- NOG-9000 Planned Engineered Lift can be used to qualify the crane for the over capacity lift
  - Capacity limitations are covered
  - Frequency limitations are covered
- Never perform an overcapacity lift without following the requirements of NOG-9000 it requires careful "Planning" and "Engineering" to do them safely.
- Never believe the design margins used in the design and the construction of the crane automatically make the crane safe for a crane overload (remember damage to a crane is sometimes hidden).

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Crane overload can misalign machinery or exceed capacity of the lubricates (this can cause extensive damage to machinery such as gears and couplings). During the over capacity lift the brakes are one of the many weak links in the hoisting system. Brakes can only absorb so much energy, once they get to hot they lose their holding capacity quickly. Electrical components should also be reviewed carefully, their design is also a weak link on the crane. The reliability found in the fatigue properties of materials in the crane can be a great concern, especially if the frequency limitations outlined in NOG-9000 are not followed. These are only a few things that must be considered.

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Back-up Material

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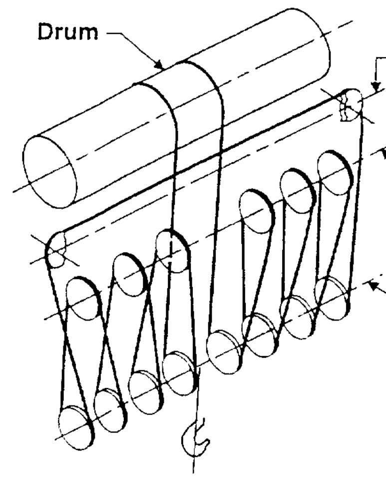

16 Part Reeving

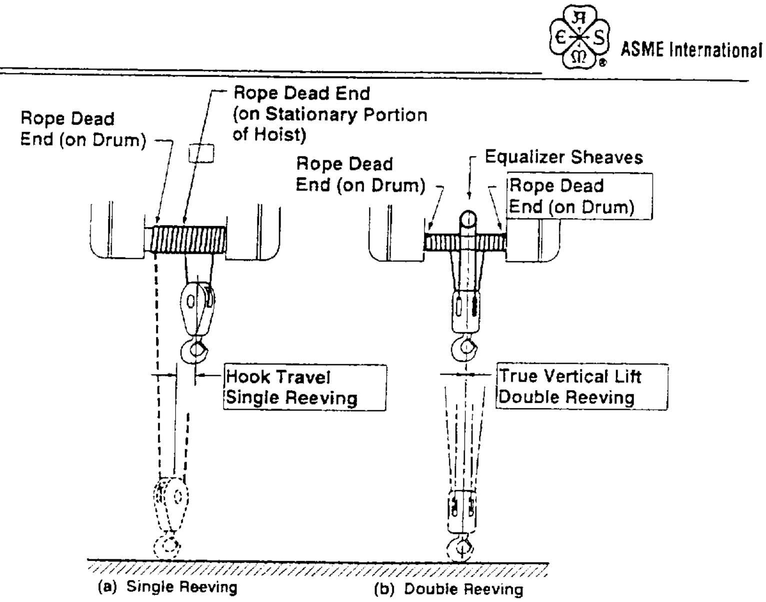

Fig. NOG-5420-2 Single and Double Reeving

ASME International

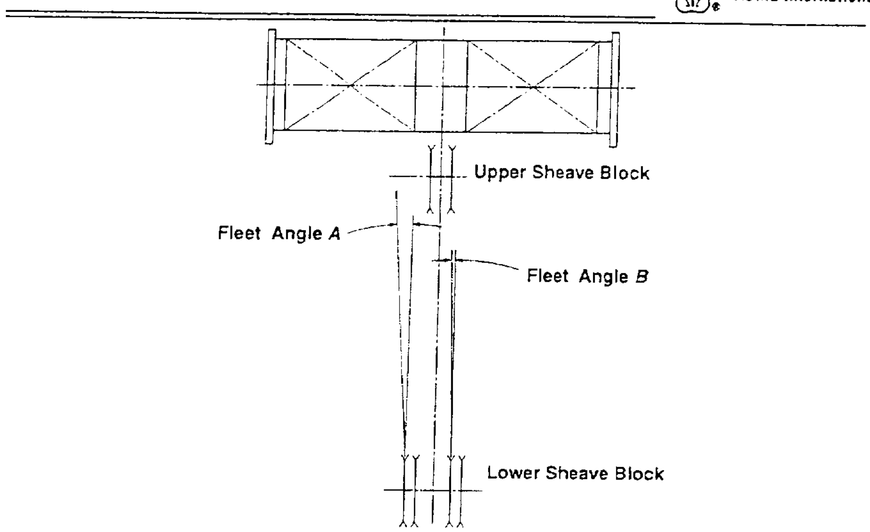

Fig. NOG-5426-1 Fleet Angles

ASME International

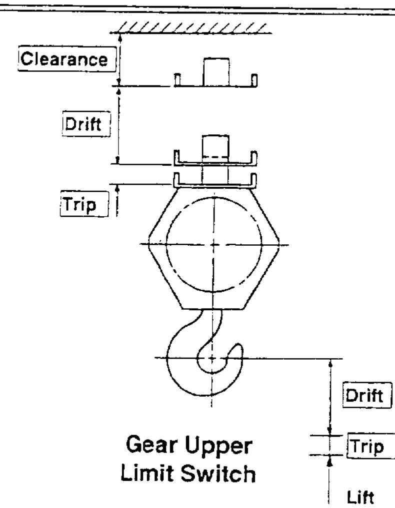

Fig. NOG-III-5459.3-1 Power or Control Circuit Limit Switch With Geared Upper Limit Switch

ASME International

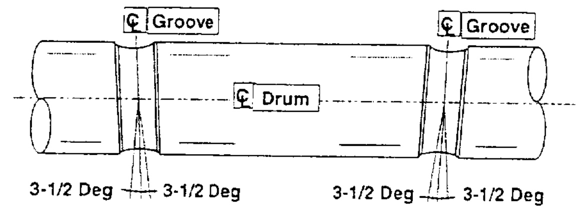

Fig. NUM-I-7942-1 Drum Fleet Angle

ASME International

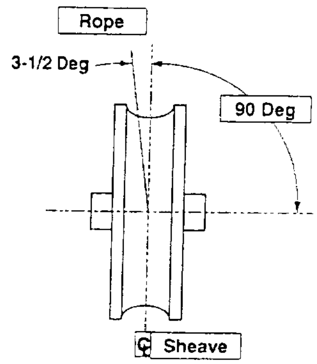

Fig. NUM-I-7942-2 Sheave Fleet Angle