What is a Rigging Engineer's Function?

Host: Mike Parnell
President/CEO, ITI
ASME B30 Vice Chair (Cranes & Rigging)
ASME P30 Chair (Lift Planning)

Guest Speaker: Matthew Dina
Rigging Engineer, Fluor Corporation

The views expressed in this presentation are that of ITI and are not necessarily the views of the ASME or any of its committees

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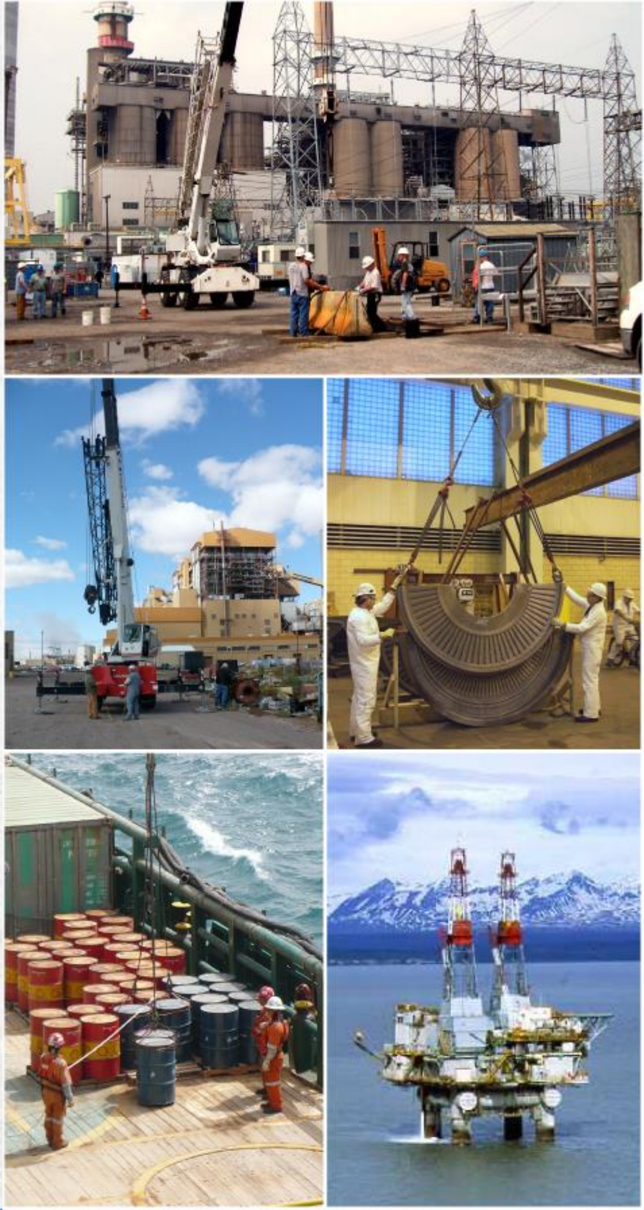

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- Rigging and Sling Failures: Case Studies and Solutions
- How to Manage a Crane Accident
- Automation - Equipment Inspection and Asset Management
- 10 Points of Lift Plan Development

Today's Presentation:

What is a Rigging Engineer's Function – FLUOR

Coming Soon:

- 9 Questions You Must Ask When Selecting a Crane and Rigging Training Provider

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- Critical Lift Planning
- Rigging Gear Inspection for Supervisors
- Advanced Rigging: Load Distribution and Center of Gravity
- Advanced Rigging: Multi-Crane Lifts and Load Turns

MIKE PARNELL – ABOUT YOUR HOST

Mr. Parnell has a wealth of knowledge regarding cranes, rigging, and lifting activities throughout a variety of industries.

- 30+ years learning about wire rope, rigging, load handling, and lifting activities.
- Vice Chair of the ASME B30 Main Committee which sets the standards in the US for cranes and rigging
- Chair of the ASME P30 Main Committee which sets the standards for lift planning.

ASME standards are also adopted by many countries around the world.

What is a Rigging Engineer’s Function?

Matthew Dina, P.E., LEED AP

Rigging Engineer

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- Over 1,000 projects annually, serving more than 600 clients in 79 different countries
- 41,000 employees executing projects globally
- Offices in 29 countries on 6 continents
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Years of Experience in Region						
North America	South America	Europe	Africa	Middle East	Asia	Australia
101	**76**	**65**	**53**	**66**	**62**	**63**

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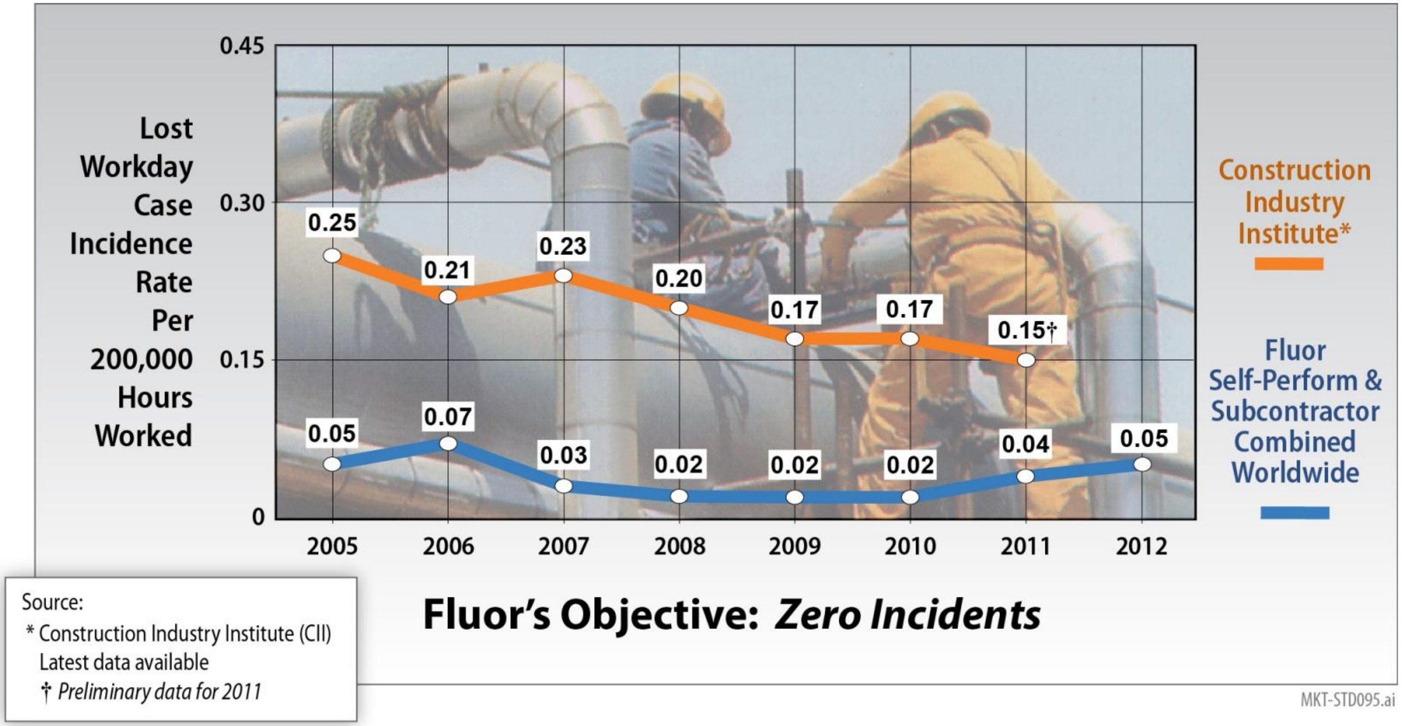

Fluor's combined self-perform and subcontractors' Lost Workday Case Incidence rates are significantly better than the average rates reported by the CII.

Today's Discussion

- **When is a Rigging Engineer involved in a project?**
- **Rigging engineers' responsibilities by project phase**
  - Construction Planning
  - Engineering / Design / Procurement
  - Pre-construction
  - Construction
  - Project Close-out

When is a Rigging Engineer involved?

- Ideally, Rigging Engineers become involved early in a project and work closely with project teams throughout project execution

- Conceptual Planning
- Engineering / Design / Procurement
- Pre-Construction
- Construction
- Project Close-out

Rigging Responsibilities

- Conceptual Planning
- Engineering / Design / Procurement
- Pre-Construction
- Construction
- Project Close-out

Conceptual Planning

- **Develop project specific rigging and lift procedures**
  - Rigging requirements
    - Client specifications
    - Design standards for rigging
  - Lift plan requirements
    - Company policy compared to Client policy
  - Personnel
    - Roles and responsibility

Rigging Responsibilities
Conceptual Planning

- **Develop project specific rigging and lift procedures** *(cont'd)*
  - Heavy haul requirements
    - Permits / local authority requirements / Army Corps of Engineers
    - Route impact analysis / route studies
    - Road / bridge condition analysis
  - Crane requirements
    - Onsite testing and inspections
    - Lift classification determination: non-critical or critical lifts

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Rigging Responsibilities

Conceptual Planning

- **Support development of construction execution strategy**
  - Modularization of equipment and structure
    - Transportation limitations
    - Identify opportunities for modularization
  - Determine crane needs to support project
    - Site walk down
    - Identify heavy haul / lift contractor(s) for budgetary estimate
    - Identify long lead items

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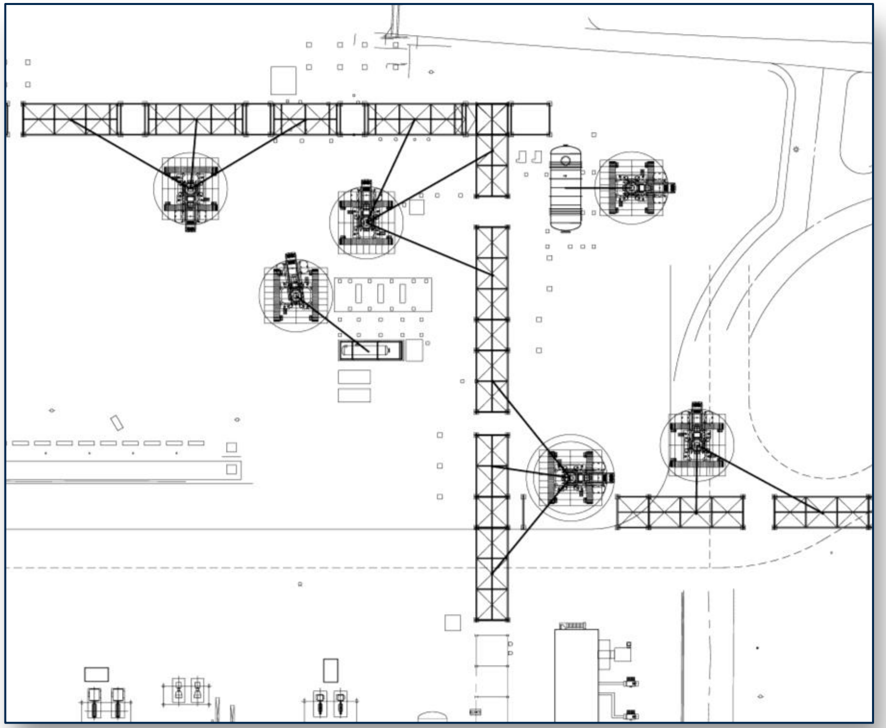
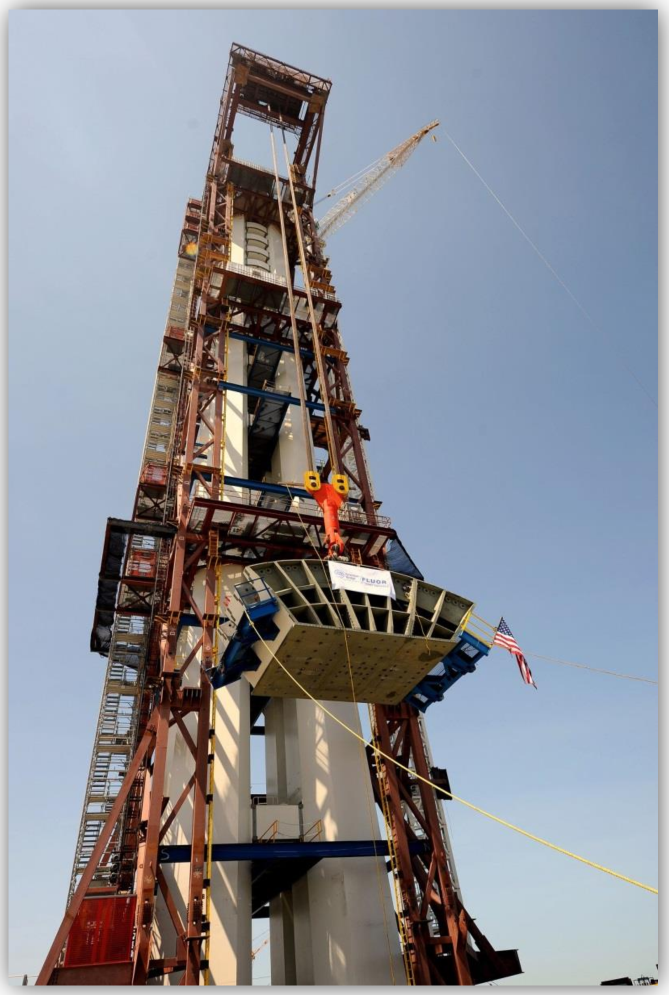
Conceptual Planning

- **Support Development of Construction Execution Strategy** *(cont'd)*
  - Participate in site and unit plot plan development
    - Preliminary crane locations
    - Transport routes
    - Fabrication areas
    - Vessel / Equipment dress-out areas
    - Identify utility interferences



Rigging Responsibilities
Conceptual Planning

- **Support development of construction execution strategy** *(cont'd)*
  - Proposed lifting solutions
    - Alternative lifting methods (jack and slide, monorails, etc…)
  - Maximize schedule and budget



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Rigging Responsibilities

- Conceptual Planning
- Engineering / Design / Procurement
- Pre-Construction
- Construction
- Project Close-out

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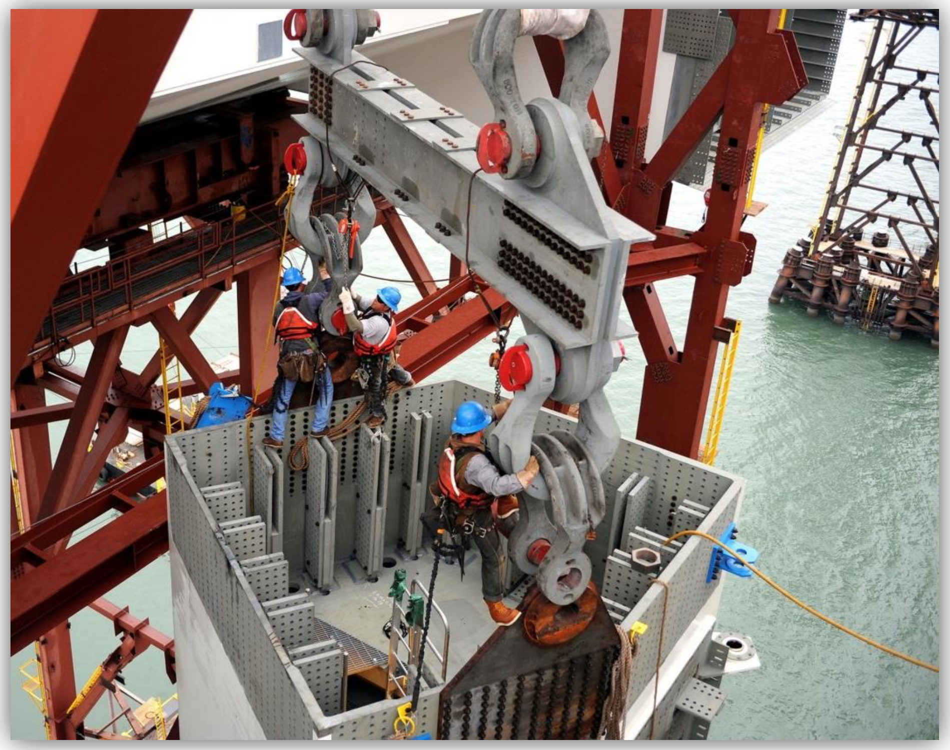
Rigging Responsibilities
Engineering / Design / Procurement

- **Participate in site and unit plot plan development in addition to crane location determination**
- **Provide rigging input into structural design and mechanical equipment**
  - Specialty rigging design
  - Lifting attachment design
- **Propose cost saving measures**
- **Finalize modularization plan**



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Rigging Responsibilities
Engineering / Design / Procurement

- **Procure long-lead items**
  - Large cranes
  - Specialty rigging
- **Determine heavy-haul transportation requirements**
  - Equipment needs
  - Coordinate selection and approval of haul route and load test if required
  - Transport beam needs
  - Coordinate with local Department of Transportation (DOT)

Rigging Responsibilities
Engineering / Design / Procurement

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PROJECT:	FLUOR CORP	3/1/2013
AREA:		Contract No.______
TITLE: Base Ring Chk	CALCULATIONS AND SKETCHES	By: ____ Chkd: ____
		Sht No. 1 of 7

1.0 DESCRIPTION:

This calculation will check the base ring stresses due to the tail load at IP (Initial Pick) position. Five seperate base ring configurations to be considered, including one point support, two point support, base ring with two lugs on top, four point support, and base ring with two external tailing beams.
Ref: Roark Formulas for Stress and Strain 4th ed., Table VIII, load cases 18 & 19.
Vessel Design Guide.

2.0 VESSEL FORCES:

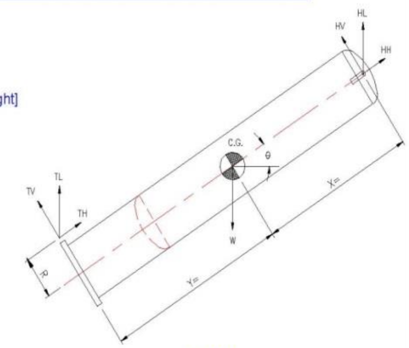
INPUT DATA:

W := 160.00·kips [Vessel erection weight]

X := 1338.00·in

Y := 1161.50·in

R := 190.00·in



SKETCH

CALCULATIONS:

$\theta := 0, 5 .. 90$ [Angle distance from I.P. position (horizontal)]

$$HL_\theta := W \cdot \frac{Y \cdot \cos(\theta \cdot deg) + R \cdot \sin(\theta \cdot deg)}{(X + Y) \cdot \cos(\theta \cdot deg) + R \cdot \sin(\theta \cdot deg)}$$ [Top load]

$HV_\theta := HL_\theta \cdot \cos(\theta \cdot deg)$ $HH_\theta := HL_\theta \cdot \sin(\theta \cdot deg)$ [Top load - Radial and Transverse]

$$TL_\theta := W \cdot \frac{X \cdot \cos(\theta \cdot deg)}{(X + Y) \cdot \cos(\theta \cdot deg) + R \cdot \sin(\theta \cdot deg)}$$ [Tail load]

$TV_\theta := TL_\theta \cdot \cos(\theta \cdot deg)$ $TH_\theta := TL_\theta \cdot \sin(\theta \cdot deg)$ [Tail load - Radial & Transverse]

PROJECT:	FLUOR CORP	3/1/2013
AREA:		Contract No.______
TITLE: Base Ring Chk	CALCULATIONS AND SKETCHES	By: ____ Chkd: ____
		Sht No. 2 of 7

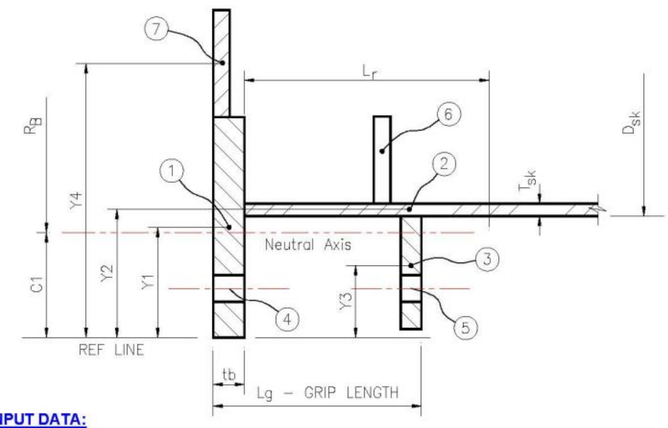
RESULTS:

Lift and Tailing Loads during lifting:

Angle	HL (kips)	HV (kips)	HH (kips)	TL (kips)	TV (kips)	TH (kips)
0	74.35	74.35	0.00	85.65	85.65	0.00
5	74.92	74.63	6.53	85.08	84.76	7.42
10	75.48	74.34	13.11	84.52	83.23	14.68
15	76.06	73.47	19.69	83.94	81.08	21.73
20	76.66	72.03	26.22	83.34	78.32	28.51
25	77.28	70.04	32.66	82.72	74.97	34.96
30	77.95	67.51	38.98	82.05	71.06	41.02
35	78.68	64.45	45.13	81.32	66.61	46.64
40	79.49	60.89	51.09	80.51	61.68	51.75
45	80.40	56.85	56.85	79.60	56.28	56.28
50	81.47	52.36	62.41	78.53	50.48	60.16
55	82.74	47.46	67.78	77.26	44.32	63.29
60	84.32	42.16	73.02	75.68	37.84	65.54
65	86.36	36.50	78.27	73.64	31.12	66.74
70	89.15	30.49	83.77	70.85	24.23	66.58
75	93.28	24.14	90.10	66.72	17.27	64.45
80	100.15	17.39	98.63	59.85	10.39	58.94
85	114.17	9.95	113.74	45.83	3.99	45.66
90	160.00	0.00	160.00	0.00	0.00	0.00

PROJECT: **FLUOR CORP** **3/1/2013**
AREA: **Contract No.______**
TITLE: Base Ring Chk **CALCULATIONS AND SKETCHES** **By: ____ Chkd: ____**
Sht No. 3 of 7

3.0 BASE RING STRESSES:



INPUT DATA:

SA 283-C	Base plate material
$Fy := 30ksi$	Base plate Yield Strength
$DF := 1.25$	Design factor
$F_b := .66 \cdot Fy$ $F_b = 19.8000\,ksi$	Allowable Base Ring Stress
$OD_b := 357.87in$	Base plate OD
$ID_b := 344.09in$	Base plate ID
$L_G := 13.78in$	Base chair grip height
$t_b := 2.36in$	Base plate thickness
$D_{sk} := 348.62in$	Skirt OD
$T_{sk} := 1.10in$	Skirt thickness
$L_r := (L_G - t_b) + .55 \cdot \sqrt{D_{sk} \cdot T_{sk}}$ $L_r = 22.1905\,in$	Effective skirt height

Note: All inputs, highlighted yellow in the table below, are in inches.

Items	Width	Height	Area	Y	AY	AY2	Io
1	6.89	2.36	16.26	3.44	55.94	192.42	64.33
2	1.10	22.19	24.41	5.18	126.44	654.95	2.46
3	6.39	2.36	15.08	1.18	17.79	21.00	51.31
(-)4	2.95	2.36	-6.96	1.47	-10.23	-15.04	-5.05
(-)5	1.77	2.36	-4.18	1.18	-4.93	-5.82	-1.09
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum1			44.61		185.01	847.51	111.96
7	4.00	2.36	9.44	8.89	83.92	746.06	12.59
Sum2			54.05		268.93	1,593.57	124.55

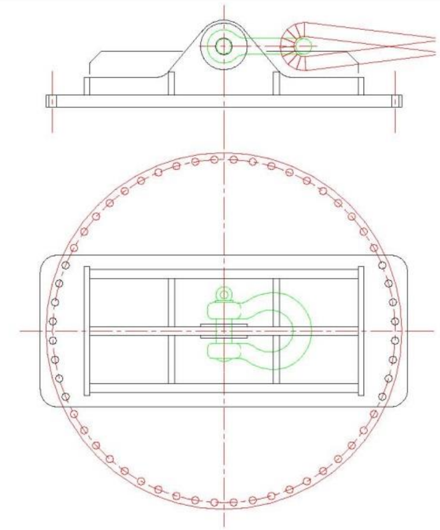
PROJECT: **FLUOR CORP** **3/1/2013**
AREA: **Contract No.______**
TITLE: Generic Flange Lug Design **CALCULATIONS AND SKETCHES** **By: ____ Chkd: ____**
Sht No. 3 of 5

3.0 Flange lug design

$Bolt := "A307"$

$n := 4$ [Number of bolts]

$BoltArea := .994in^2$



Check bolt stresses:

Shear stress on each bolt:

$$f_{v_\theta} := \frac{HV_\theta}{n \cdot BoltArea}$$

For combined tension and shear on bolts: (bearing-type connections)

Allowable tension stress on bolts:

For A307 bolts: $Ft1_\theta := (26 \cdot ksi - 1.8 \cdot f_{v_\theta})$ $Ft1_\theta := if(Ft1_\theta < 20ksi, Ft1_\theta, 20ksi)$ Ref: AISC 9th ed. page 5-74.

For A325 bolts: $Ft2_\theta := \sqrt{(44ksi)^2 - 4.39 \cdot (f_{v_\theta})^2}$

$$Ft_\theta := \begin{cases} Ft1_\theta & \text{if } Bolt = "A307" \\ Ft2_\theta & \text{if } Bolt = "A325" \end{cases}$$

Allowable shear stress on bolts: (when threads are included in shear planes)

$$Fv_\theta := \begin{cases} 0.17 \cdot 60ksi & \text{if } Bolt = "A307" \\ 21ksi & \text{if } Bolt = "A325" \end{cases}$$

Actual tensile stress on each bolt:

$$f_{t_\theta} := \left(\frac{HH_\theta}{n \cdot BoltArea}\right) \cdot 1.80$$

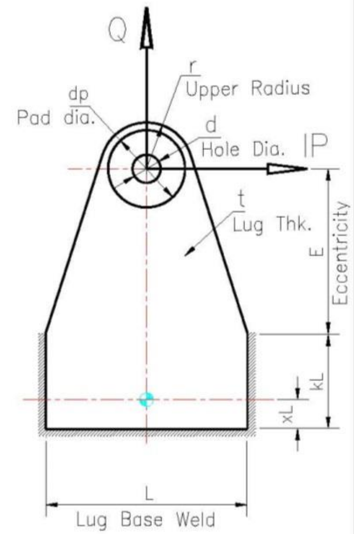
Actual shear stress on each bolt:

$$f_{vact_\theta} := \frac{HV_\theta}{n \cdot BoltArea} \cdot 1.8$$

3.0 LIFT LUG DESIGN

INPUT:

Lug plate material:	SA 516-70
Lug Allowable Yield:	$Fy := 0.262 \frac{kN}{mm^2}$
Vessel Shell thickness:	$ts := 2in$
Vertical load per lug:	$Q := \frac{1}{2} \cdot TL_0$
	$Q = 474.77\,kips$
Initial pick load per lug:	$IP := \frac{1}{2} \cdot TH_{70}$
	$IP = 201.28\,kips$
Impact factor:	$DF := 1.8$
Electrode Coefficient:	$C1 := 1$
Lug thickness:	$t := 102mm$
Lug eccentricity:	$E := 500mm$
Lug Base Weld:	$L := 1000mm$
Lug Side Weld	$kL := 250mm$
Lug Pin Hole Diameter	$d := 160mm$
Lug Upper Radius	$r := 300mm$
Lug Pad Thickness (If required)	$tp := 45mm$
Lug Pad Dia (If required)	$dp := 330mm$
Shackle Pin Diameter	$sp := 150mm$
Shackle Inside Width at Pin	$wp := 200mm$



Engineering / Design / Procurement

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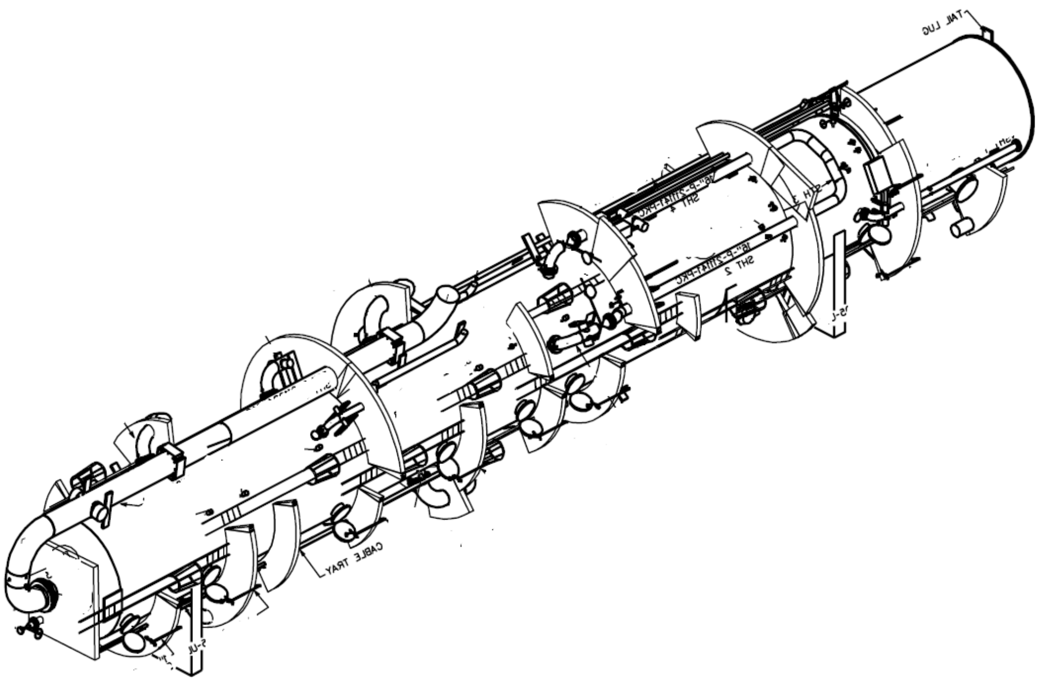
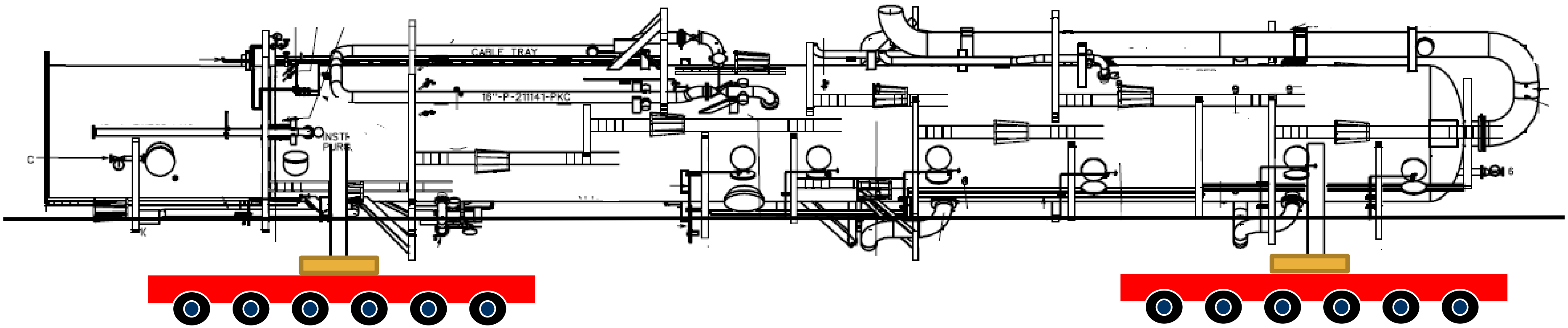
Rigging Responsibilities
Engineering / Design / Procurement

- **Dressed columns**
  - Construction issues for transportation and erection



Rigging Responsibilities
Engineering / Design / Procurement

◆ Transportation



Shipping saddles **need to be** **…**

- **Tall**, to clear dressing
- **Wide**, stable so that the column can be moved
- **Attached to the column** for transportation stability
- **Located just above a platform** to access completing the insulation
- **Included in the model**, so that piping is designed to clear them

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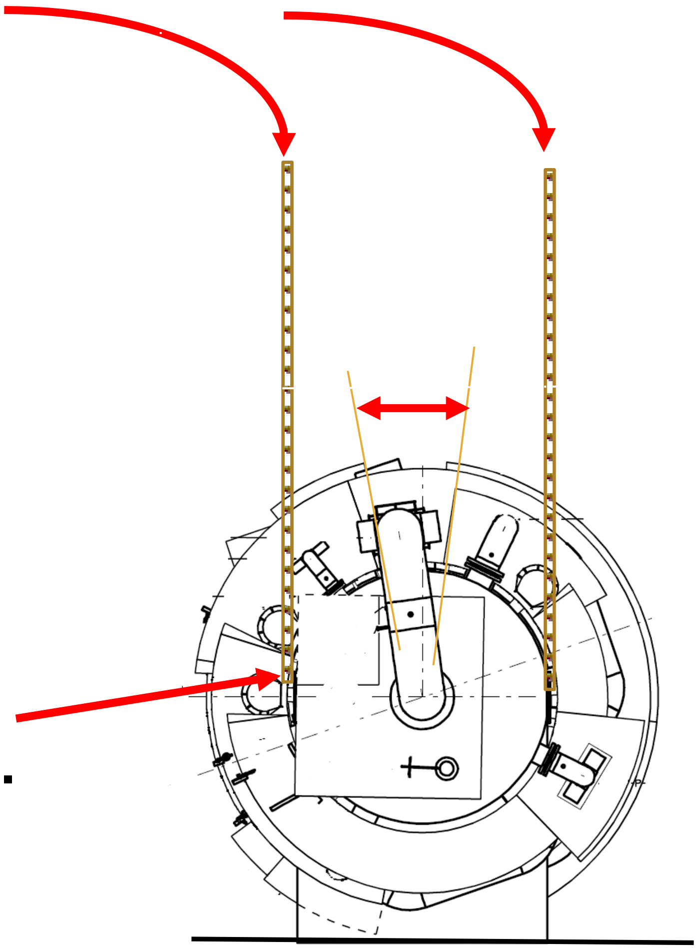
- **Top piping / platforms**

Lifting slings

Top platform to clear lifting slings.

- If platform needs to be larger, use a bolt-on section to extend platform
- Design the extension so that it can be easily fitted as men will need to work from a crane basket

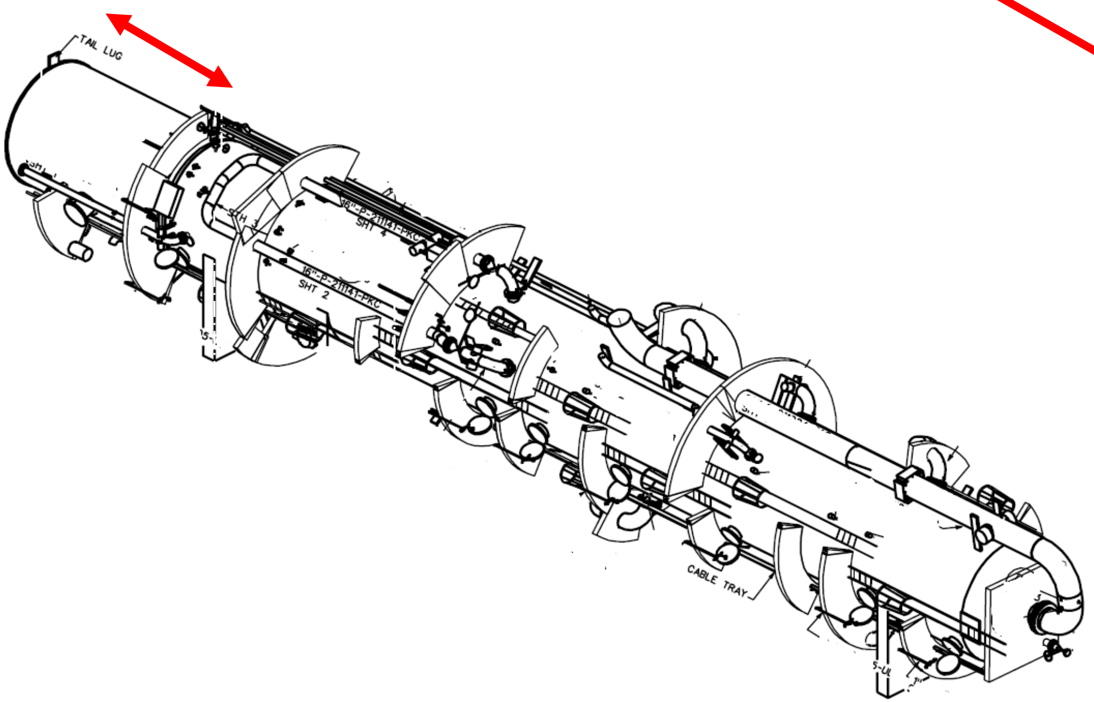
Lifting lugs to project through the insulation.

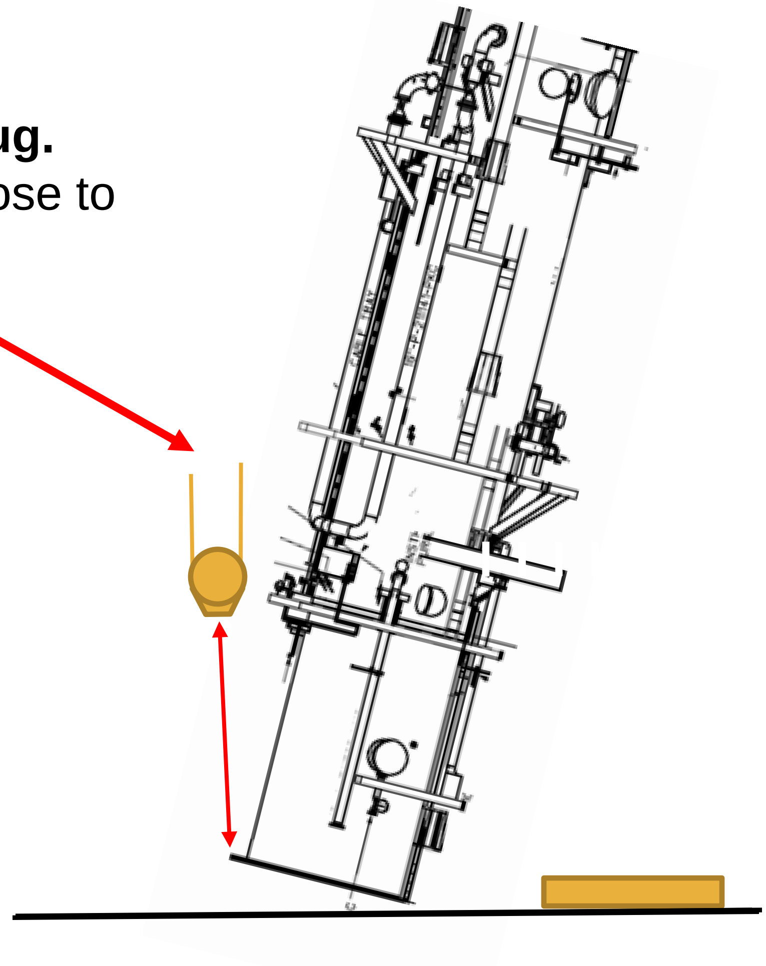


Engineering / Design / Procurement

- **Tailing lug**

Platforms to be clear of tailing lug.
Rigging and crane block comes close to column as it is upended.





Rigging Responsibilities

- Conceptual Planning
- Engineering / Design / Procurement
- Pre-Construction
- Construction
- Project Close-out

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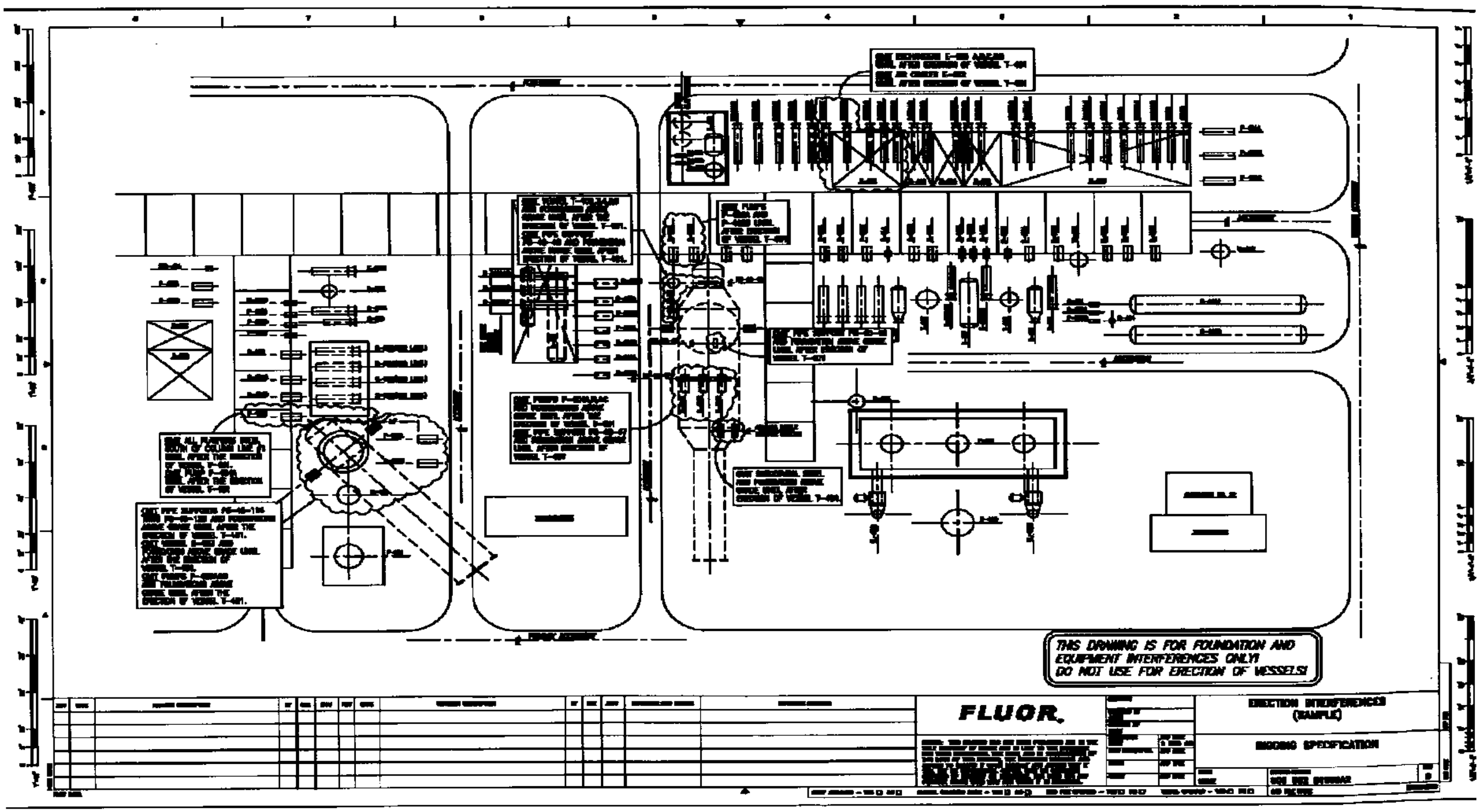
Rigging Responsibilities

Pre-Construction

- **Selection of Haul / Lift Subcontractor(s)**
  - Short-lead items
  - Review bids / assist with final selection
- **Finalize crane plot layouts**
- **Confirm ground bearing requirements**
  - Remediate as necessary per soils evaluation

Rigging Responsibilities
Pre-Construction

- Identify erection interferences on plot plans



Rigging Responsibilities
Pre-Construction

- **Assist with rigging hardware procurement**
  - General site rigging – slings, shackles, spreaders, etc.
- **Identify potential critical lifts**
  - Review equipment lists as input
- **Start generating lift and rigging plans**
- **Support selection of cranes and other lifting equipment**
- **Support initial mobilization of cranes**

Rigging Responsibilities

- Conceptual Planning
- Engineering / Design / Procurement
- Pre-Construction
- Construction
- Project Close-out

Rigging Responsibilities
Construction

- **Manage heavy-haul / lift subcontractor(s)**
  - Permit oversight
  - Haul route preparation
  - Crane assembly / disassembly and inspections
  - Crane location verification including mat pads
  - Work with site rigging superintendents and / or supervisors

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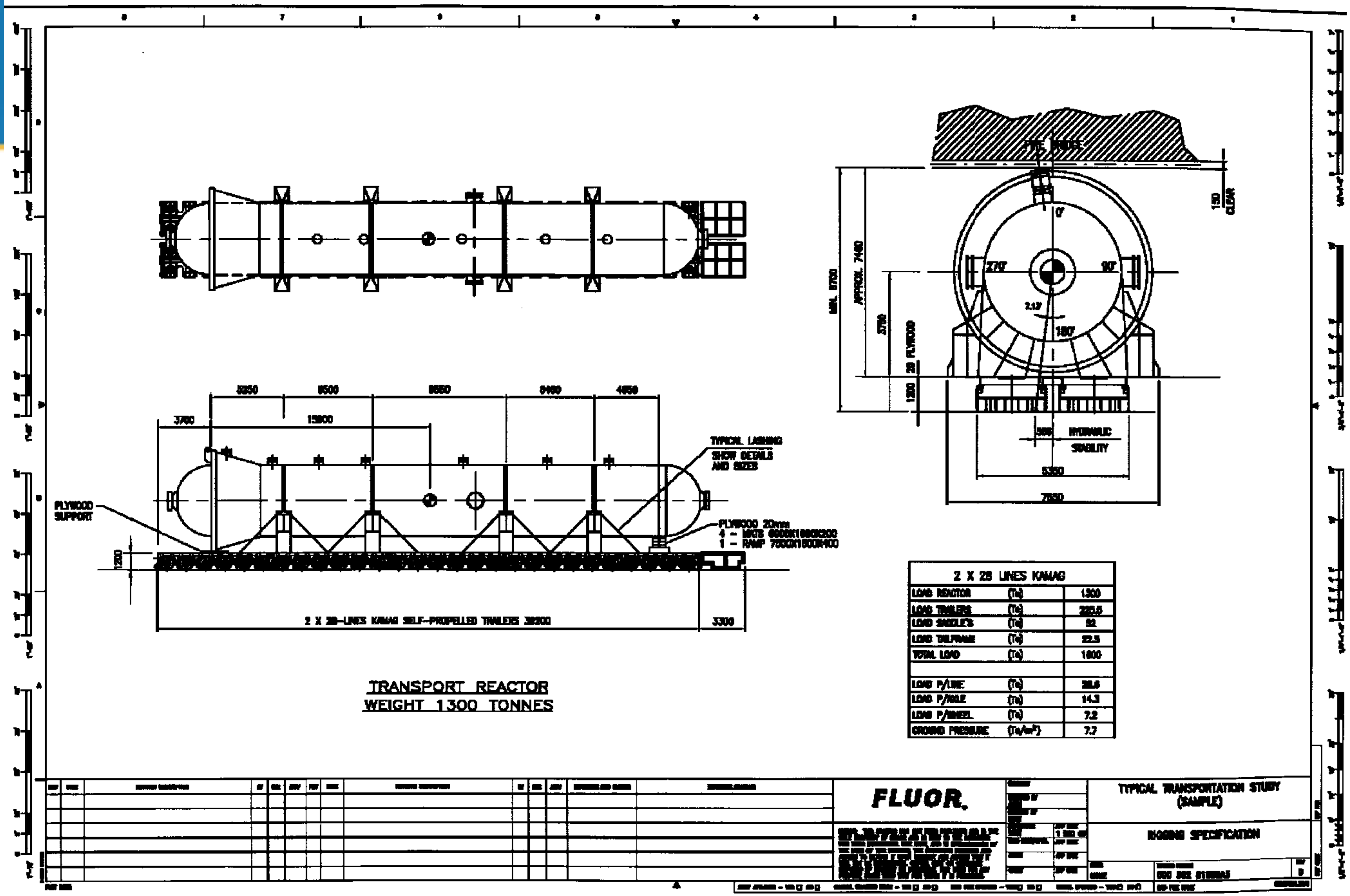

2 X 28 LINES KAMAG		
LOAD REACTOR	(Te)	1300
LOAD TRAILERS	(Te)	225.5
LOAD SADDLES	(Te)	52
LOAD TAILFRAME	(Te)	22.5
TOTAL LOAD	(Te)	1600
LOAD P/LINE	(Te)	28.6
LOAD P/AXLE	(Te)	14.3
LOAD P/WHEEL	(Te)	7.2
GROUND PRESSURE	(Te/m²)	7.7

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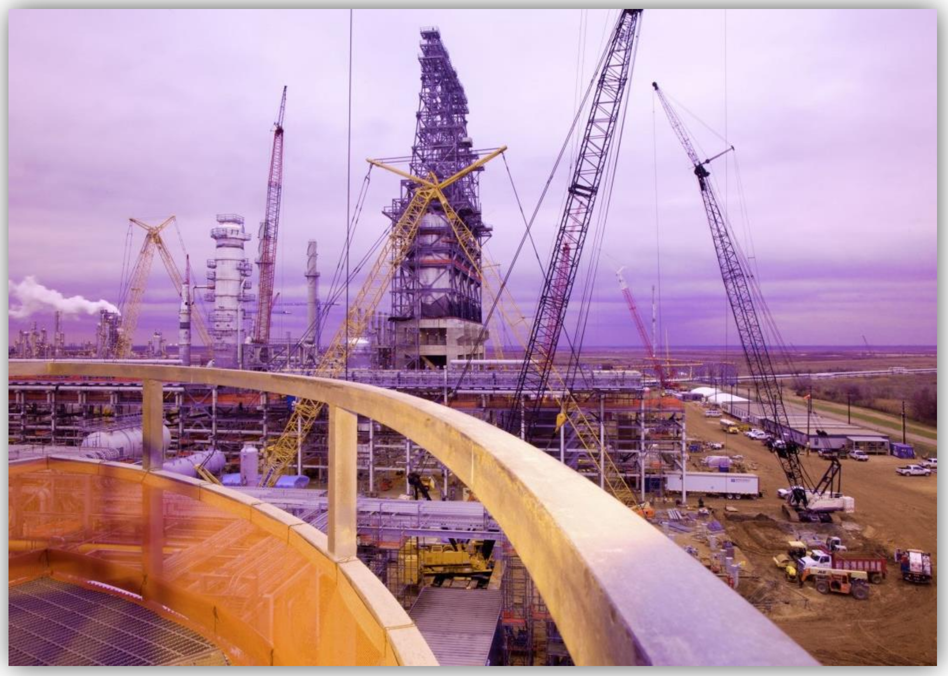
Rigging Responsibilities
Construction

- Design temporary support / guying systems
- Assist with procurement of rigging hardware
- Provide rigging input to onsite preassemblies
- Provide onsite rigging / lift plan training



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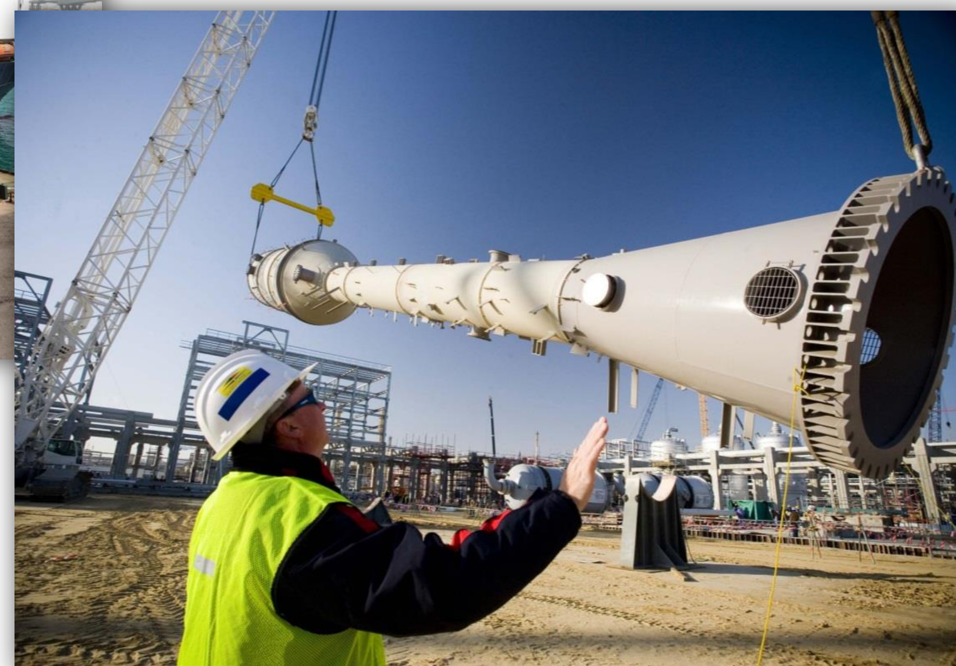
Rigging Responsibilities
Construction



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Rigging Responsibilities
Construction

- **Onsite pre-assemblies**

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Rigging Responsibilities
Construction

Develop & Issue Rigging / Lift Plans

- **Knowledge of:**
  - **Host-country crane**
  - **Rigging requirements**
  - **Local OSHA / safety regulations**
- **Type of rigging hardware, weights and capacities**
- **Plot layout with final setting location**
- **Method of delivery for the equipment**
- **Dimensions, weight, center of gravity and lifting attachments for the equipment**

Rigging Responsibilities
Construction

Develop & Issue Rigging / Lift Plans *(cont'd)*

- **Ground bearing applied during lift by outrigger, track, etc…**
- **Potential interferences**
  - Existing plant equipment
  - Power lines
  - Etc…
- **Underground utilities, excavations, catch basins / manholes, voids, etc…**
- **Load charts and other equipment instructions**
- **Load ratings for lifting equipment**
  - Dimensions of proposed crane and components: tail swing, boom length, assembly space, etc…
- **Equipment manufacturer's lifting / handling instructions**

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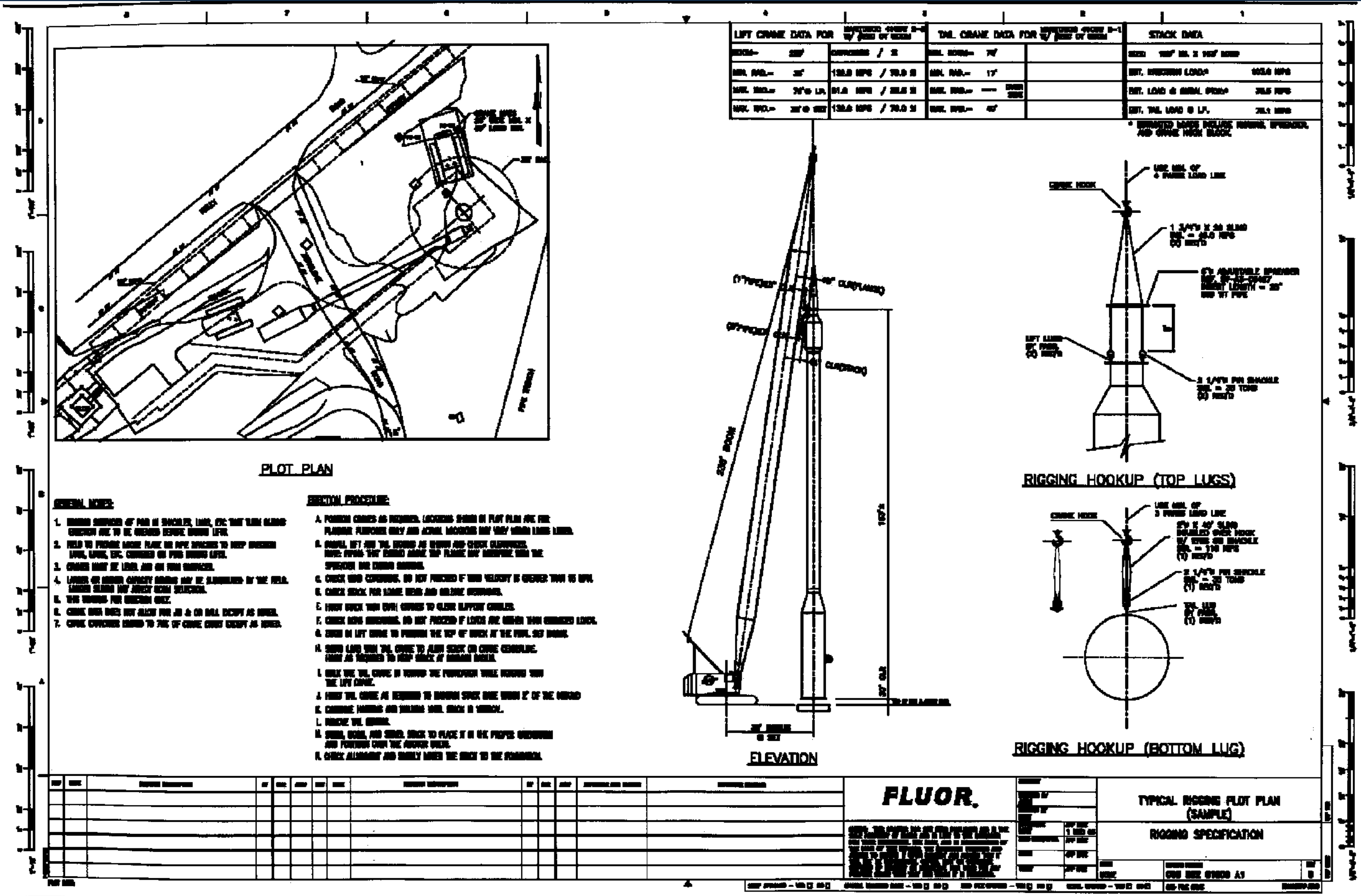
LIFT CRANE DATA FOR
TAIL CRANE DATA FOR
STACK DATA
PLOT PLAN
GENERAL NOTES:
ERECTION PROCEDURE:
230' BOOM
ELEVATION
CRANE HOOK
RIGGING HOOKUP (TOP LUGS)
RIGGING HOOKUP (BOTTOM LUG)
FLUOR
TYPICAL RIGGING PLOT PLAN (SAMPLE)
RIGGING SPECIFICATION

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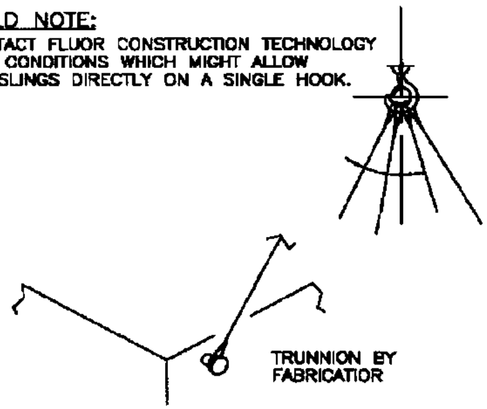
F-AP.DWG 01APR01

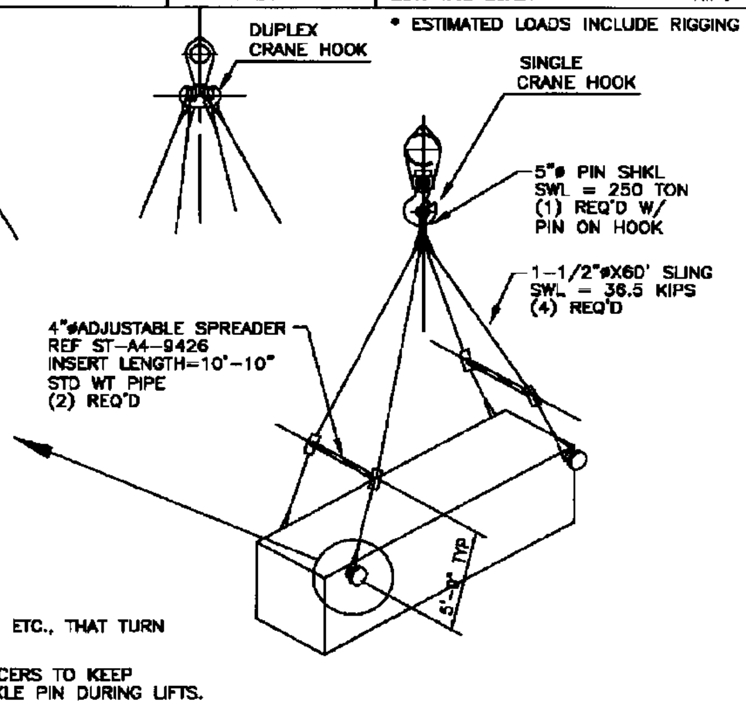
LIFT CRANE DATA FOR: 4100W S-2		TAILING CRANE DATA FOR: ---		LOAD DATA SIZE: 40'L x 12'W x 6'H x 79.5 KIPS	
MIN. BOOM = 170'	MAX. BOOM = 200'	MIN. BOOM = --	MAX. BOOM = --	EST. ERECTION WT.*	86.00 KIPS
MIN. RAD. = 31'	MIN. RAD. = 34'	MIN. RAD. = --	MIN. RAD. = --	EST. I.P. LOAD: *	-- KIPS
MAX. RAD. = 55'	MAX. RAD. = 55'	MAX. RAD. = --	MAX. RAD. = --	EST. TAIL LOAD: *	-- KIPS

* ESTIMATED LOADS INCLUDE RIGGING

FIELD NOTE:
CONTACT FLUOR CONSTRUCTION TECHNOLOGY FOR CONDITIONS WHICH MIGHT ALLOW (4) SLINGS DIRECTLY ON A SINGLE HOOK.



TYPICAL 4 PLACES



RIGGING HOOK-UP

NOTES:

1. BEARING SURFACES OF PINS IN SHACKLES, LUGS, ETC., THAT TURN ARE TO BE GREASED BEFORE MAKING LIFTS.
2. FIELD IS TO PROVIDE LOOSE PLATE OR PIPE SPACERS TO KEEP ERECTION LUGS, LINKS, ETC CENTERED ON SHACKLE PIN DURING LIFTS.
3. LOADS DO NOT INCLUDE WEIGHT OF JIB AND OVERHAUL BALL.
4. ERECTION LUGS TO BE SHOP WELDED TO THE UNIT BY FABRICATOR.
5. CRANES MUST BE LEVEL AND ON FIRM SURFACES.
6. THIS DRAWING FOR ERECTION ONLY.

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RIGGING SPECIFICATION

RIGGING DATA SHEET (SAMPLE)

PLOT DATE | REV | BY | DATE | REVISION DESCRIPTION | APPV | DSGN | MGR | CHK | MGT | SUPVR | MGT | DATE 1 DEC 00 | CONTRACT | SCALE | CAD FILE NAME | DRAWING NUMBER 000 502 01000A4 | REV 0 | CLIENT | APPROVAL FLUOR | RFQ07A.DWG

DIST CODE | SAP NWA

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Rigging Responsibilities
Construction

Oversight of lifting operations

- **Distribute lift / rigging plans to Client and proper field personnel involved with lifting operations**
- **Assist in the inspection of the crane setup and rigging hookup per plan**
    - Crane in proper location
    - Crane boom / components correct per plan
    - Rigging gear sized correctly per lift plan

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Oversight of lifting operations *(cont'd)*

- **Involvement in pre-lift meetings**
- **Facilitate health, safety and environmental (HSE) and management reviews**
- **Facilitate approvals of plans, as required, by adopted site policy**
- **Monitor lifting operations to ensure safe execution of lift**
  - Monitor wind and other environmental conditions
  - Monitor outriggers or crawler tracks for settlement during lifts
- **Initiate field changes to plans if needed while adhering to site policy**

Projects

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Rigging Responsibilities

- Conceptual Planning
- Engineering / Design / Procurement
- Pre-Construction
- Construction
- Project Close-out

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Project Close-Out

- Subcontract close-out and evaluation
- Construction debriefing report

Comments & Questions

Matthew Dina
Rigging Engineer