Lift Systems, Inc.
Vertical Cask Transporter,
Part Number CT201072

DATA PACKAGE
LSI-ZS-VCT-2012
REVISION 1

Lift Systems, Inc.
Vertical Cask Transporter

CLIENT / PROJECT	Zion*Solutions* Kewaunee
EQUIPMENT DESCRIPTION	Vertical Cask Transporter (VCT)
PART NUMBER	CT201072
MANUFACTURED BY	Lift Systems, Inc. East Moline, IL

Lift Systems, Inc.
Vertical Cask Transporter

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10.0	VCT Ladder
11.0	On-site Kewaunee Inspections
12.0	Operational Manual (with recommended spares) (Submitted separately)

Section 1.0
NAC Certificate of Conformance

NAC INTERNATIONAL

Atlanta Corporate Headquarters
3930 East Jones Bridge Road, Suite 200
Norcross, GA 30092
Phone 770-447-1144
Fax 770-447-1797
www.nacintl.com

NAC INTERNATIONAL CERTIFICATE OF CONFORMANCE

ZIONSOLUTIONS, LLC – ZION NUCLEAR POWER STATION
April 26, 2012

COMPONENT SUPPLIED

Lift Systems, Inc. - Vertical Cask Transporter (VCT)
Quantity – 1
Quality Category—Non-Quality Related

IDENTIFICATIONS

1. Equipment Specification Sheet (ESS), ESS-018, Revision 3
2. Lift Systems, Inc. Drawing, NAC 180 TON Transporter To Handle The NAC MAGNASTOR-E Cask At The Zion Nuclear Power Plant, Part Number CT201072, Rev B, 1-21-11
3. Zion*Solutions* Contract No. 215555-001, Amendment 6
4. NAC Purchase Order to Lift Systems - Number 805164, Revision 2

CERTIFICATIONS

NAC International certifies that the above listed VCT is furnished in accordance with the requirements of the Zion*Solutions* Contract, ESS-018, and Lift Systems drawing listed above.

The VCT was factory load tested and operationally/functionally tested as specified in ESS-018, Revision 3.

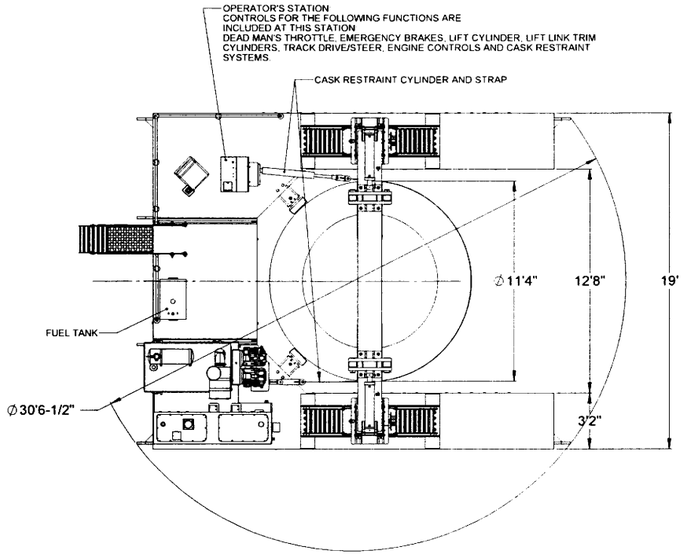
This certification and the associated fabrication documentation package for these components are provided to Zion*Solutions*, LLC at the following address:

Zion*Solutions*, LLC
Zion Nuclear Power Station
101 Shiloh Blvd
Zion, IL, 60099

Allan Altera
Project Manager

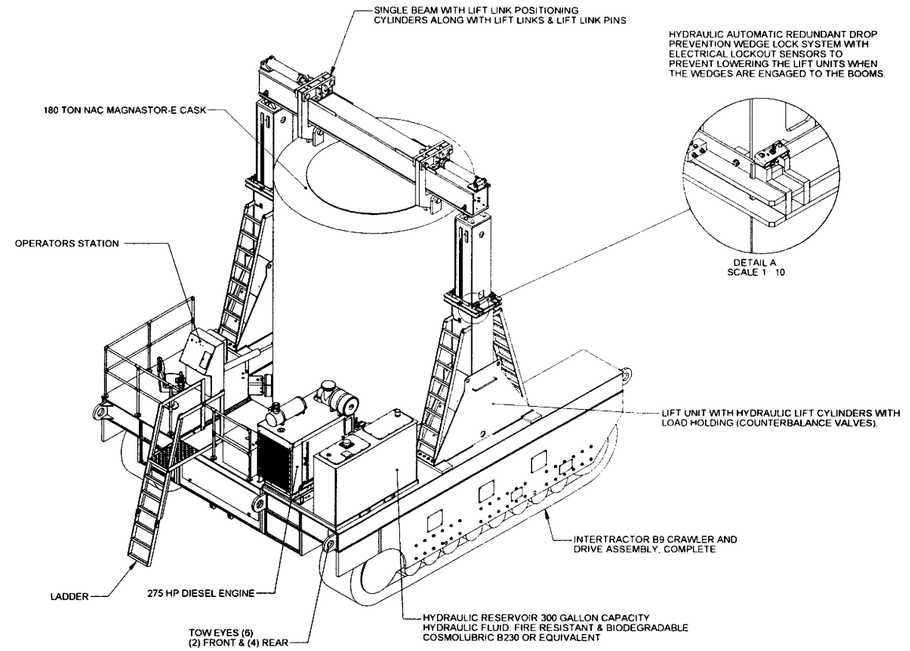
4/26/12
Date

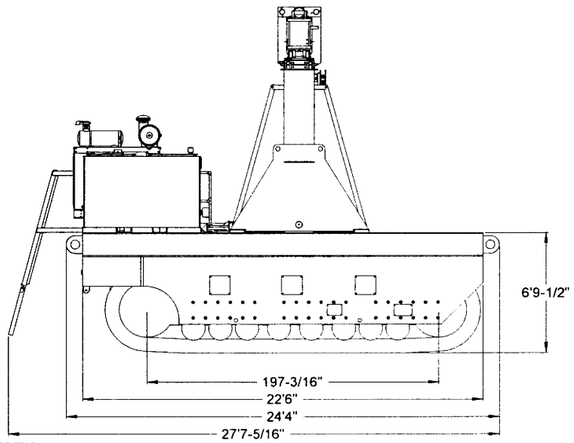
Section 2.0
VCT Drawing

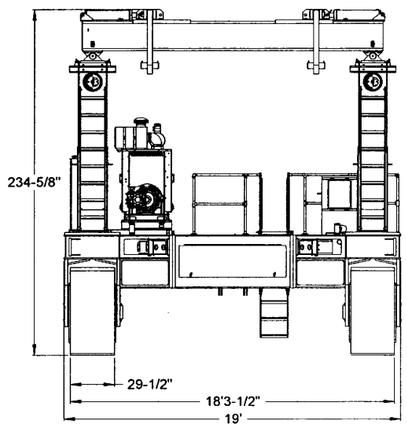


TRANSPORTER DATA:

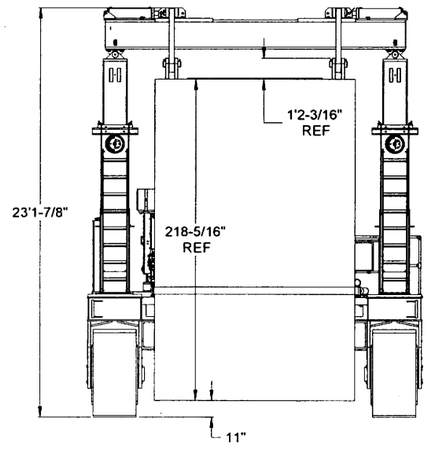
- RATED CAPACITY 180 TONS.
- 167,000 LBS EMPTY WEIGHT.
- 527,000 LBS FULLY LOADED, WITH 180 TON NAC MAGNASTOR-E CASK.
- FULL LOAD AUTOROTATION CAPABILITY.
- HEADER BEAM AND LIFT LINKS AND LIFT LINK PINS ARE DESIGNED IN ACCORDANCE WITH ANSI N14.6.
- WELDING IS IN ACCORDANCE WITH AWS D1.1, STRUCTURAL WELDING CODE.
- LEVEL II QUALIFIED PERSONNEL TO NON DESTRUCTIVELY EXAMINE ALL LOAD BEARING WELDS AND ASSEMBLIES IN ACCORDANCE WITH ANST USING MPI METHOD.
- ENVIRONMENTAL CONDITIONS: RAIN AND SNOW, 0° F TO 104° F AT 0% TO 100% HUMIDITY.
- NIL-DUCTILITY TEMPERATURE CRITERIA APPLIES TO FERRITIC PLATE ONLY IN LOAD PATH FOR OPERATIONS DOWN TO 0 DEG F. IMPACT TESTING AT -10 DEG F.
- RAW MATERIAL DESIGNATION IN ACCORDANCE WITH ASTM OR AISI STANDARDS.
- SLINGS IN ACCORDANCE WITH ASME B30.9.
- LIFT UNITS IN ACCORDANCE WITH ASME B30.1-2009 HYDRAULIC GANTRIES.
- LIFT UNITS IN ACCORDANCE WITH SAE J1078 - A RECOMMENDED METHOD OF ANALYTICALLY DETERMINING THE COMPETENCE OF HYDRAULIC TELESCOPIC CANTILEVERED BOOMS.
- VERTICAL C.G., LESS THAN 75" WITH NO LOAD AT MAXIMUM LIFT HEIGHT.
- DIESEL ENGINE - CUMMINS 6.7 LITER INDUSTRIAL "QSB" SERIES. 275 HP @ 2500 RPM.
- DIESEL FUEL TANK CAPACITY: 40 GALLONS MINIMUM TO 50 GALLONS MAXIMUM.
- TRAVEL SPEED (LOADED) 0.5 MPH ON LEVEL GROUND.
- MAXIMUM GRADE 10%.
- MAXIMUM SIDE TO SIDE SLOPE 4%.
- AVERAGE GROUND BEARING PRESSURE = 46 PSI WITH 180 TON PAYLOAD.
- AUTOMATIC WEDGELOCK SYSTEM, A REDUNDANT DROP PREVENTION SYSTEM REPLACING MANUAL PINS.
- NIGHT LIGHTING SYSTEM (4 FRONT AND 4 REAR), LOCATIONS TBD.
- C.A.R.L. (Computer Assisted Remote Lifting) CONTROL SYSTEM. CONSOLE MOUNTED CONTROL DISPLAY PROVIDING ACCURATE LIFT HEIGHTS FOR BOTH THE L.H. & R.H. LIFT UNITS. DISPLAY CAN BE "ZEROED OUT" AT THE PUSH OF A BUTTON BY THE OPERATOR AT THE CONSOLE.
- RADIO REMOTE CONTROL OF LIFTING, SIDESHIFT AND DRIVE FUNCTIONS THROUGH THE C.A.R.L. SYSTEM.
- FACTORY OPERATIONAL TESTING AT 100% RATED LOAD.
- FACTORY STATIC PROOF LOAD TESTING AT 125% RATED LOAD.
- PAINT SYSTEMS IS AN EPOXY BASE COAT PRIMER AND A POLYURETHANE TOP COAT.
- BASIC MACHINE WIDTH 18'-4", WIDTH FOR CASK TRAILER VERSION 19'-0".



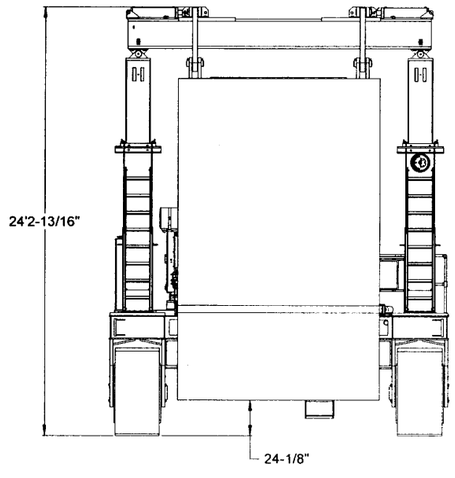




FULLY RETRACTED POSITION



CASK IN TRAVEL POSITION



CASK IN FULLY EXTENDED POSITION

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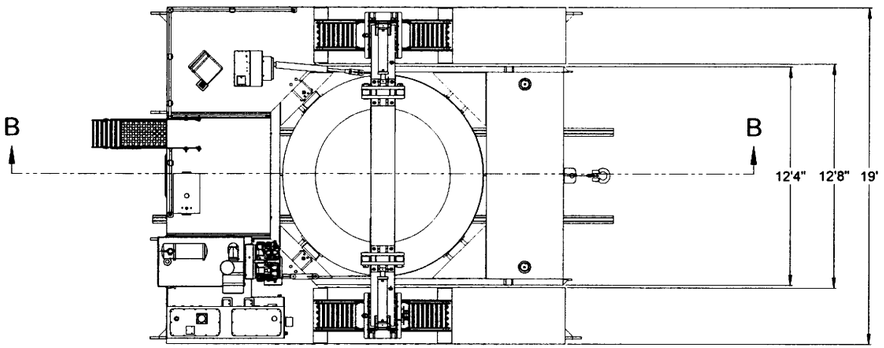
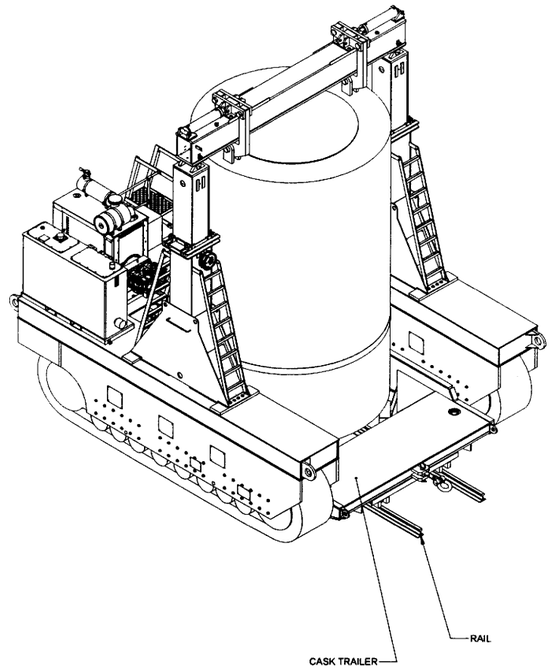
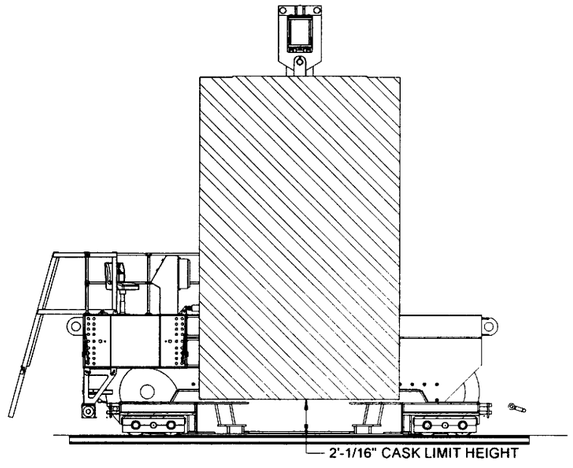
NEXT ASSEMBLY
ESTIMATED WEIGHT

REVISIONS
A-ADDED SHEET FOR MAGNASTOR CONFIGURATION - CRP 3-10-2011
B-UPDATED LOW PROFILE TRANSFER CART VIEWS ON SHEET 2 CRP 2-1-2012

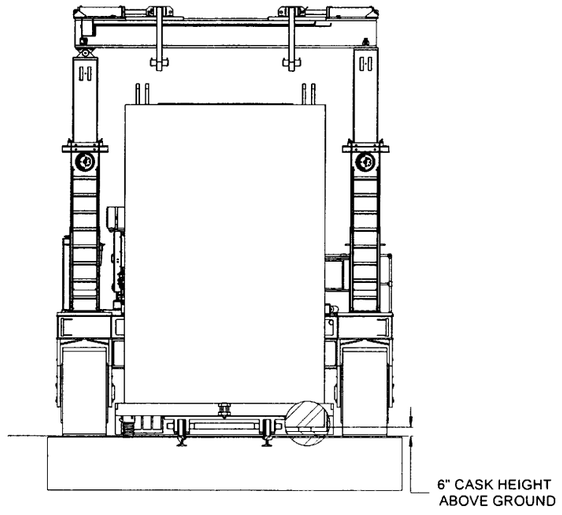
TOLERANCES (EXCEPT AS NOTED)	LIFT SYSTEMS, INC.		
DECIMAL	SCALE 1:50	DRAWN BY CRP	APPR BY RAS
FRACTIONAL ± 1/16"	TITLE: NAC 180 TON TRANSPORTER TO HANDLE THE NAC MAGNASTOR-E CASK AT THE ZION NUCLEAR POWER PLANT		SIZE D
ANGULAR ± 1/2°	DATE 1-21-2011	PART NUMBER CTZ01072	REV B
		SHEET 1 OF 3	

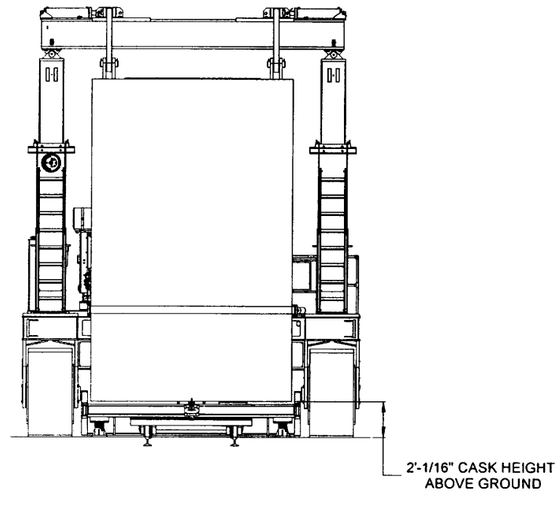






SECTION B-B





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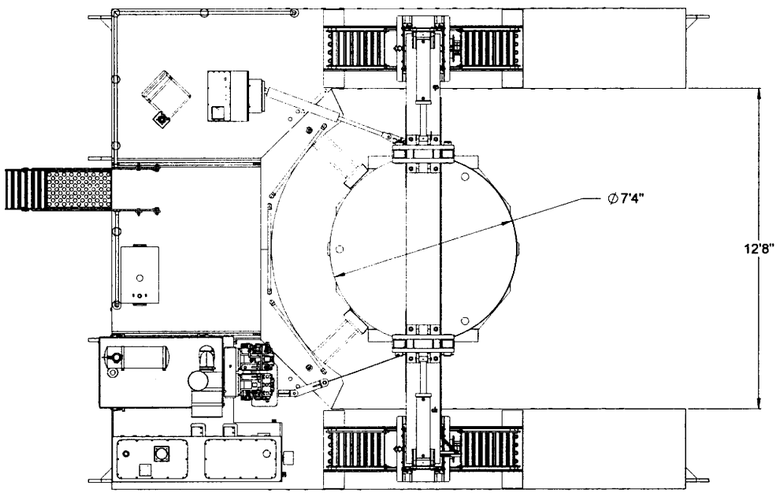
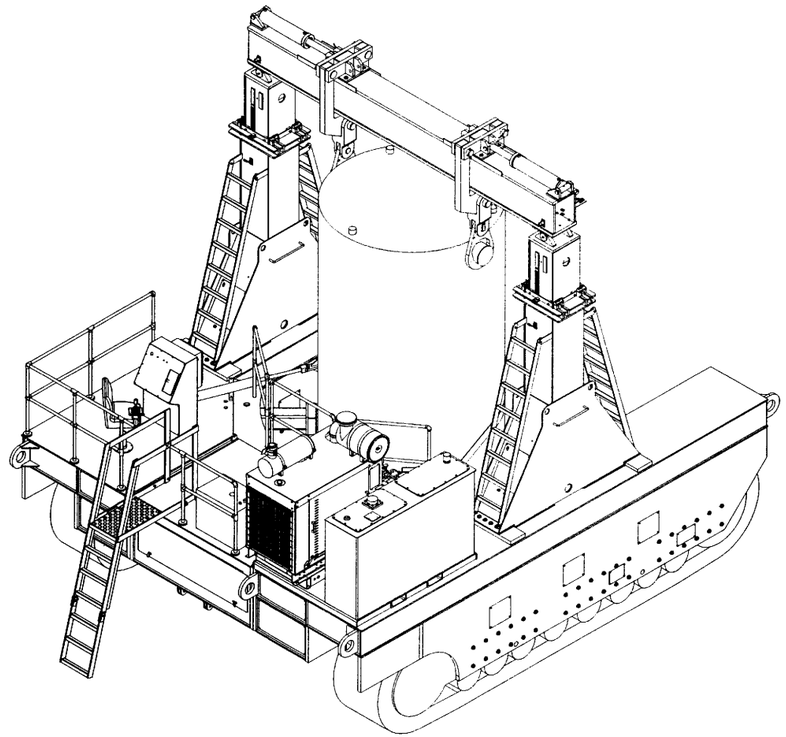
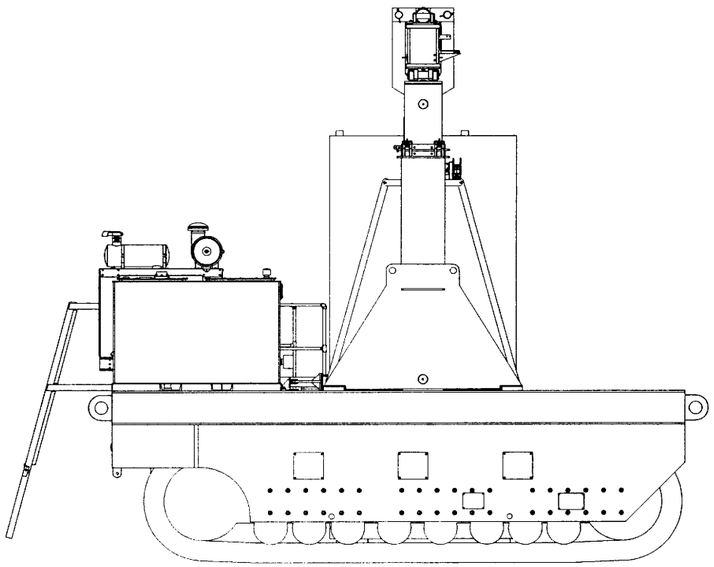
NEXT ASSEMBLY
ESTIMATED WEIGHT: 432,746 378 LBS

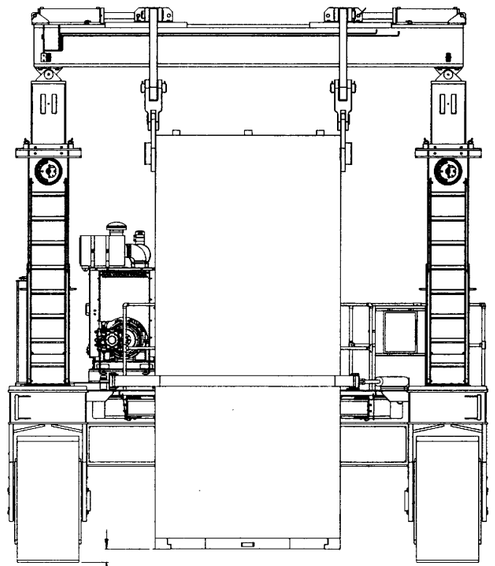
REVISIONS
A-ADDED SHEET FOR MAGNASTOR CONFIGURATION - CRP 3-10-2011
B-UPDATED LOW PROFILE TRANSFER CART VIEWS ON SHEET 2
CRP 2-1-2012

TOLERANCES (EXCEPT AS NOTED)	LIFT SYSTEMS, INC.		
DECIMAL .xxx ± .005 .xx ± .010 .x ± .030	SCALE 1:50	DRAWN BY CRP	APPR BY RAS
FRACTIONAL ± 1/16"	TITLE NAC 180 TON TRANSPORTER TO HANDLE THE NAC MAGNASTOR-E CASK AT THE ZION NUCLEAR POWER PLANT		SIZE D
ANGULAR ± 1/2°	DATE 1-21-2011	PART NUMBER CT201072	REV. B
			SHEET 2 OF 3









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NEXT ASSEMBLY
ESTIMATED WEIGHT

REVISIONS
A-ADDED SHEET FOR MAGNASTOR CONFIGURATION - CRP 3-10-2011
B-UPDATED LOW PROFILE TRANSFER CART VIEWS ON SHEET 2
CRP 2-1-2012

TOLERANCES (EXCEPT AS NOTED)	LIFT SYSTEMS, INC.		
DECIMAL .xxx ± .005 .xx ± .01 .x ± .1	SCALE 1:35	DRAWN BY CRP	APPR BY RAS
FRACTIONAL ± 1/16"	TITLE NAC 180 TON TRANSPORTER TO HANDLE THE NAC MAGNASTOR-E CASK AT THE ZION NUCLEAR POWER PLANT		SIZE D
ANGULAR ± 1/2°	DATE 1-21-2011	PART NUMBER REV B	CT201072 SHEET 3 OF 3

Section 3.0
Structural Calculation

DESIGN CALCULATION FILE

SPENT FUEL STORAGE CASK TRANSPORTER

FOR

NAC INTERNATIONAL, INC

ZION NUCLEAR POWER STATION

Prepared for

LIFT SYSTEMS, INC.

Report No. 8708-318

Rev. 0

February 24, 2012

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Section 2.0 - Vendor Data

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O & K Final Drives (3 pages)
Mannesmann Rexroth Motors (8 pages)
Sauer Sundstrand Pumps (8 pages)
Durst Gear Reducers (2 pages)
Cummins Engine (4 pages)
Prince Manufacturing Hydraulic Cylinders (1 page)
Lamco Web Slings (1 page)

SECTION 1.0 - DESIGN CALCULATIONS

DESIGN LOADS AND CRITERIA

Loads...

Rated Capacity	180	tons (ESS-018 §2.)
Vehicle Test Load Multiplier	125%	(ESS-018 §2.)
Cylinder Test Load Multiplier	125%	(ESS-018 §2.)
Vertical Impact Factor	15.00%	(Lift Systems design standard)
Lateral Inertia Load Factor	2.50%	(Lift Systems design standard)
Longitudinal Inertia Load Factor	2.50%	(Lift Systems design standard)
Operational Wind Speed	35	mph (Lift Systems design standard)
Extreme Wind Speed (for stability)	115	mph (ASCE/SEI 7-10 for Zion, IL)
Maximum Road Grade	10.00%	(ESS-018 §3.)
Maximum Road Superelevation (for strength)	4.00%	(ESS-018 §3.)
Maximum Road Superelevation (for stability)	4.00%	(ESS-018 §3.)
Maximum Travel Speed	0.50	(ESS-018 §3.)
Stopping Distance from 0.50 mph	8.00	feet (Lift Systems design standard)
Maximum Allowable Empty Vehicle Weight	167,000	pounds (ESS-018 §2.)
Maximum Allowable Average Ground Bearing Pressure	50	psi (ESS-018 §3.)

Allowable Stresses - Upper Structure...

For Cask Attachment Pins:

Allowable Shear Stress	0.19	Fy (ANSI N14.6 §4.2.1.1)
or	0.15	Fu (ANSI N14.6 §4.2.1.1)
Maximum Allowable Bending Stress	0.33	Fy (ANSI N14.6 §4.2.1.1)
or	0.20	Fu (ANSI N14.6 §4.2.1.1)
Allowable Tension Stress	0.33	Fy (ANSI N14.6 §4.2.1.1)
or	0.20	Fu (ANSI N14.6 §4.2.1.1)

For Lift Links:

Allowable Shear Stress	0.19	Fy (ANSI N14.6 §4.2.1.1)
or	0.15	Fu (ANSI N14.6 §4.2.1.1)
Maximum Allowable Bending Stress	0.33	Fy (ANSI N14.6 §4.2.1.1)
or	0.20	Fu (ANSI N14.6 §4.2.1.1)
Allowable Tension Stress	0.33	Fy (ANSI N14.6 §4.2.1.1)
or	0.20	Fu (ANSI N14.6 §4.2.1.1)

For Header Beams:

Allowable Shear Stress	0.19	Fy (ANSI N14.6 §4.2.1.1)
or	0.15	Fu (ANSI N14.6 §4.2.1.1)
Allowable Major Axis Bending Stress	0.33	Fy (ANSI N14.6 §4.2.1.1)
or	0.20	Fu (ANSI N14.6 §4.2.1.1)
Allowable Minor Axis Bending Stress	0.33	Fy (ANSI N14.6 §4.2.1.1)
or	0.20	Fu (ANSI N14.6 §4.2.1.1)
Allowable Bending Stress for Round Pins	0.33	Fy (ANSI N14.6 §4.2.1.1)
or	0.20	Fu (ANSI N14.6 §4.2.1.1)
Allowable Tension Stress	0.33	Fy (ANSI N14.6 §4.2.1.1)
or	0.20	Fu (ANSI N14.6 §4.2.1.1)
Allowable Bearing Stress	0.90	Fy (AISC §J8)

For All Other Structural Members:

Allowable Shear Stress	0.40	Fy (SAE J1078)
Allowable Bending Stress	0.60	Fy (SAE J1078)
Allowable Bending Stress for Round Pins	0.96	Fy [AISC F11.1 (not addressed in J1078)]
Allowable Tension Stress	0.60	Fy (SAE J1078)
Allowable Column Buckling Stress	variable	Fy (SAE J1078)
Allowable Bearing Stress	0.90	Fy [AISC J7 (not addressed in J1078)]
Allowable Cylinder Hoop Stress	0.50	Fy (ASME B30.1-2009)
Allowable Cylinder Axial Load	0.50	Pcr (ASME B30.1-2009)

WIND LOAD CALCULATION - ASCE 7-10 METHOD

Input Data...

Basic Wind Speed, V	35	mph
Occupancy Category (from Table 1.5-1, page 2)	III	
Directionality Factor, Kd (Table 26.6-1, page 250)	0.95	
Exposure Category (from Section 26.7.3, page 251)	C	
Kzt (from Figure 26.8-1, page 252)	1.00	

Dimensions for Cask Area:

Height	18.54	feet = 222.50 inches
Diameter	11.33	feet = 136.00 inches

Dimensions for Transporter Structure Gross Area:

Vertical Dimension	24.29	feet *
Horizontal Dimension	8.74	feet *

Wind Load Calculations...

alpha (from Table 26.9-1)	9.50	
zg (from Table 26.9-1)	900.00	feet
Kz (from Table 29.3-1)	0.94	
c (from Table 26.9-1)	0.20	
L (from Table 26.9-1)	500.00	feet
epsilon (from Table 26.9-1)	0.20	
z min (from Table 26.9-1)	15.00	feet
Iz (from Eq. 26.9-7)	0.23	
Lz (from Eq. 26.9-9)	427.06	
Q (from Eq. 26.9-8)	0.94	
Gust Factor, G (from Eq.26.9-6)	0.89	
Velocity Pressure, qz (from Eq. 29.3-1)	2.80	psf
h/D (for cask)	1.64	
Cf (from Figure 29.5-1)	0.82	
Design Wind Pressure, p (from Eq. 29.5-1)	2.06	psf on cask area
Projected Vertical Area, Af	210.14	ft.^2
Total Force, F	**433**	**pounds on cask**
Aspect Ratio, Width/Height (for transporter)	0.36	
Cf (from Figure 29.4-1)	1.56	
Design Wind Pressure, p (Eq. 29.5-1)	3.91	psf on transporter area
Projected Vertical Area, Af	212.25	ft.^2
Total Force, F	**829**	**pounds on transporter**

* Note: The Transporter side area exposed to the wind is approximately 212 square feet. The height of the Transporter (rounded off) is 24 feet, as shown. The width dimension is equal to 212/24 = 8.74 feet. Approximating the wind area as a rectangle simplifies the wind load calculations. Since the actual area distribution is closer to the ground than this rectangle, this simplification gives a conservative result with respect to the wind effect on the Transporter.

LIFT LINK PINS

Design Load...

Tension Load	207.00	kips per pin

Cask Lugs to Lift Link Dimensions...

Lift Link Thickness	3.500	inches
NAC Cask Lifting Lug Thickness	2.000	inches
Clear Between Lifting Lugs	4.200	inches
Pin Diameter	4.000	inches
Pin Length	12.000	inches
Steel Grade	ASTM A564 Type 630 H925	
Pin Fy	155	ksi
Pin Fu	170	ksi

Pin Stress Analysis...

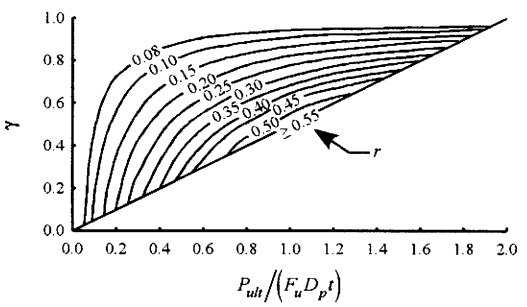
Shear Area	12.57	in.^2
Maximum Shear	103.50	kips
fv	8.24	ksi
Fv	25.50	ksi
Shear S.R.	**0.32 ≤ 1.00**	**O.K.**
Lift Link r (net end distance / thickness)	0.99	
Lift Link Ultimate Load, P'u	2,089.76	kips
P'u / (Ap Fu)	1.49	
Melcon & Hoblit Reduction Factor	0.75	(see figure below)
Width of Pin Bearing to Lift Link	= M & H Factor x Thickness / 2	
=	1.31	inches each side
Pin Moment Arm	2.00	inches
Maximum Moment	207.32	kip-inches
Section Modulus	6.28	in.^3
fb	33.00	ksi
Fb	34.00	ksi
Bending S.R.	**0.97 ≤ 1.00**	**O.K.**

Lift Link Pin Dead Weight...

Lower Lift Link Pin	43	pounds each

Pin Design Curves...

This figure is a reproduction of the referenced figure from the Melcon & Hoblit paper:



LIFT LINKS

Design Load...

Tension Load	207.04	kips

Dimensions and Properties...

Top Bar Spacing, in-to-in	4.250	inches
Top Bar Thickness	2.000	inches
Top Bar Depth at Ends	6.500	inches
Top Bar Depth at Center	6.500	inches
Center Hole Diameter	0.000	inch
Top Edge to Hole CL	0.000	inch
Corner Hole Diameter	3.550	inches
CL Corner Hole to Bottom Edge	3.250	inches
Top Bar Width	29.000	inches
Top Bar Span	23.000	inches
Top Bar Fy	100	ksi (ASTM A514)
Top Bar Fu	110	ksi (ASTM A514)
Side Bar Thickness	3.500	inches
Side Bar Width	6.000	inches
Side Bar Hole Diameter	3.550	inches
CL Hole to End of Bar	3.250	inches
Side Bar Fy	100	ksi (ASTM A514)
Side Bar Fu	110	ksi (ASTM A514)
Bottom Bar Thickness	3.500	inches
Bottom Bar Depth at Ends	6.000	inches
Bottom Bar Depth at Center	12.000	inches
Bottom Center Hole Diameter	4.100	inches
Bottom Edge to Hole CL	5.500	inches
Bottom Bar Width	29.000	inches
Bottom Bar Fy	90	ksi (ASTM A514)
Bottom Bar Fu	100	ksi (ASTM A514)
Assembly Pin Diameter	3.500	inches
Pin Fy	125	ksi (ASTM A564 Type 630 H1075)
Pin Fu	145	ksi (ASTM A564 Type 630 H1075)
Thickness of Side Shift Plate + Nylatron Pads	1.500	inches

Segment Properties...

Top Bar Center Area	13.000	in.^2
Top Bar Center y bar	3.250	inches from top edge
Top Bar Center Ix	45.771	in.^4
Top Bar c	3.250	inches
Top Bar End Av	4.404	in.^2 (one shear plane)
Side Bar Hole Effective Width	1.225	inches each side of hole
Side Bar Net Area	8.575	in.^2
Side Bar Hole Av	15.414	in.^2 (two shear planes)
Bottom Bar Center Area	27.650	in.^2
Bottom Bar Center y bar	6.259	inches from bottom edge
Bottom Bar Center Ix	478.449	in.^4
Bottom Bar Center c	6.259	inches
Bottom Bar Center Hole Av	29.854	in.^2 (two shear planes)
Header Beam Web Spacing, c-c	13.000	inches
Lift Link Pin Diameter	4.000	inches

LIFT LINKS

Component Analyses...

Top Bar Moment Arm	5.000 inches		
Top Bar Moment (one bar carries 50%)	258.80 kip-inches	=	18.38 ksi
Top Bar Shear (one bar carries 50%)	51.76 kips	=	11.75 ksi
Side Bar Pin Hole Tension	103.52 kips each	=	12.07 ksi
Side Bar Pin Hole Shear	103.52 kips	=	6.72 ksi
Bottom Bar Moment Arm	11.50 inches		
Bottom Bar Upper Bound Moment	1,190.50 kip-inches	=	15.58 ksi
Bottom Fiber Bending Stress		=	15.58 ksi
Center Pin Hole Shear	207.04 kips	=	6.94 ksi
Center Pin Hole Bearing	207.04 kips	=	14.79 ksi
Bottom Bar Shear	103.52 kips	=	4.93 ksi
Assembly Pin Moment	116.46 kip-inches	=	27.67 ksi
Assembly Pin Shear	51.76 kips	=	5.38 ksi
Assembly Pin Bearing - Top Bar		=	7.39 ksi
Assembly Pin Bearing - Side Bar		=	8.45 ksi

Allowable Stresses...

Top Bar:		
Top Bar Ld/t^2	37.38	
Bending	22.00	ksi
Shear	16.50	ksi
Bearing	41.67	ksi
Side Bars:		
Tension	22.00	ksi
Shear	16.50	ksi
Bearing	41.67	ksi
Bottom Bar:		
Bottom Bar Ld/t^2	22.53	
Bending	20.00	ksi
Tension	20.00	ksi
Shear	15.00	ksi
Bearing	37.50	ksi
Assembly Pins:		
Bending	29.00	ksi
Shear	21.75	ksi
Bearing	52.08	ksi

Stress Ratios...

Top Bar Moment	0.84 ≤ 1.00 O.K.
Top Bar Shear	0.71 ≤ 1.00 O.K.
Top Bar Bearing	0.18 ≤ 1.00 O.K.
Side Bar Pin Hole Tension	0.55 ≤ 1.00 O.K.
Side Bar Pin Hole Shear	0.41 ≤ 1.00 O.K.
Side Bar Bearing	0.20 ≤ 1.00 O.K.
Bottom Bar Moment	0.78 ≤ 1.00 O.K.
Bottom Bar Shear	0.33 ≤ 1.00 O.K.
Bottom Bar Center Pin Hole	0.46 ≤ 1.00 O.K.
Center Hole Bearing	0.39 ≤ 1.00 O.K.
Bottom Fiber Sigma	0.98 ≤ 1.00 O.K.
Assembly Pin Moment	0.95 ≤ 1.00 O.K.
Assembly Pin Shear	0.25 ≤ 1.00 O.K.

SIDE SHIFT BRACKETS

Side Shift System Data...

Cylinder Bore Diameter	6.000	inches
Cylinder Rod Diameter	3.000	inches
Operating Pressure	3,000	psi
Rod End Cylinder End Width	4.000	inches
Barrel End Cylinder End Width	6.750	inches
Side Shift Coefficient of Friction	0.18	(Nylatron on dry steel)
Side Shift Coefficient of Friction	0.24	(increase by 1/3 to account for contamination)
Number of Slider Pad Bolts	4	
Bolt Diameter	3/4	inch
Allowable Shear	13.25	kips (SAE Grade 8)

Bracket Dimensions and Properties...

	Lift Link:	Header Beam:
Hole Diameter, inches	1.515	1.515
End Radius, inches	1.750	1.500
Side Radius, inches	2.750	1.500
Thickness, inches	1.250	1.000
Length of Lug Plate at Base, inches	4.875	8.000
CL Hole Above Base, inches	2.750	3.500
Clear Between Lug Plates, inches	4.125	7.000
Fy, ksi	100	100
Fu, ksi	110	110
Weld Size, inches	3/8	3/8
Weld Filler Strength, ksi	110	110
Pin Diameter, inches	1.500	1.500
Fy, ksi	100	100

Cylinder Evaluation...

Lift Link Vertical Load	208.06	kips
Friction Resistance	49.94	kips
Maximum Cylinder "Pull" Force	63.62	kps
Cylinder Utilization Ratio	**0.78 ≤ 1.00**	**O.K.**

Lug Plate Analyses...

Design Side Shift Load per Lift Link, kips	49.94	
Load per Lug Plate, kips	24.97	
Main Plate be, inches	1.993	0.743
Main Plate b eff, inches	1.993	0.743
Main Plate a, inches	0.993	0.743
Net Section Pult, kips	547.94	163.35
Beyond Hole Shear Pult, kips	287.51	197.01
Bearing Pult, kips	337.50	270.00
ASD Design Factor for Pin Hole	2.00	2.00
Allowable Load at Pin Hole, kips	143.76	81.68
Pin Hole S.R.	**0.17**	**0.31 ≤ 1.00 O.K.**

SIDE SHIFT BRACKETS

Weld Analysis...

	Lift Link:	Header Beam:
Length of Weld All Around, inches	12.25	18.00
Sx of Weld All Around, in.^2	14.02	29.33
Weld v, kips per inch	5.31	3.29
Weld V, kips per inch	8.75	8.75
Weld S.R.	**0.61**	**0.38 ≤ 1.00 O.K.**

Pin Analyses...

Pin Load, kips	49.94	49.94
Shear Area, in.^2	1.77	1.77
Maximum Shear, kips	24.97	24.97
fv, ksi	14.13	14.13
Fv, ksi	40.00	40.00
Shear S.R.	**0.35**	**0.35 ≤ 1.00 O.K.**
Section Modulus, in.^3	0.33	0.33
Maximum Moment, kip-inches	29.65	24.97
fb, ksi	89.48	75.35
Fb, ksi	95.81	95.81
Bending S.R.	**0.93**	**0.79 ≤ 1.00 O.K.**
Minimum Bearing Area, in.^2	3.75	3.00
Bearing Force, kips	49.94	49.94
fp, ksi	13.32	16.65
Fp, ksi	90.00	90.00
Bearing S.R.	**0.15**	**0.18 ≤ 1.00 O.K.**

Slider Pad Bolt Analysis...

Shear Load per Bolt	12.48 kips
Allowable Shear	13.25 kips
Bolt Shear S.R.	**0.94 ≤ 1.00 O.K.**

HEADER BEAM

Loads and Dimensions...

Lift Link Vertical Reaction	208.06	kips, including impact	
Lift Link Longitudinal Reaction 1	13.11	kips	See notes on Page 9
Lift Link Longitudinal Reaction 2	21.02	kips	for load assumptions
Lifting Link Spacing	9.42	feet = 113.00 inches	
Maximum Side Shift off Center	0.08	feet	
Header Beam Span	15.83	feet	
Header Beam Total Length	17.00	feet	

Beam Section Properties...

Shape Designation	Fab. Box	
Unit Weight	279	pounds per foot
Total Weight	7,425	pounds
Depth	20.000	inches
Web Thickness	1.000	inch
Web Spacing, c-c	13.000	inches
Flange Width	16.000	inches
Flange Thickness	1.500	inches
Fy	100	ksi (ASTM A514)
Fu	110	ksi (ASTM A514)
Web-to-Flange Fillet Weld Size	3/8	inch
Filler Strength	110	ksi
Ix	4,935	in.^4
Sx	493	in.^3
Iy	2,463	in.^4
Sy	308	in.^3

Stress Calculations...

Maximum Supported Load Beam Reaction	210.25	kips
Minimum Supported Load Beam Reaction	205.87	kips
Beam Dead Load Mx	104.93	kip-inches
Supported Load Mx	8,132.05	kip-inches
Total Mx	8,236.97	kip-inches
fbx	16.69	ksi
Fbx	22.00	ksi
My	821.67	kip-inches
fby	2.67	ksi
Fby	22.00	ksi
Bending S.R.	**0.88 ≤ 1.00**	**O.K.**
Vertical Shear	212.46	kips
fv	5.31	ksi
Fv	16.50	ksi
Shear S.R.	**0.32 ≤ 1.00**	**O.K.**
Weld v	4.78	kips per inch per web
Weld V	6.19	kips per inch per web
Weld S.R.	**0.77 ≤ 1.00**	**O.K.**

Header Beam Deflection...

Supported Load without Impact	180.51	kips per point
Mid-Span Deflection (Load Centered)	0.207	inch = L / 917
Allowable Deflection	0.317	inch (based on CMAA #70)
Deflection Ratio	**0.65 ≤ 1.00**	**O.K.**

HEADER BEAM ASSEMBLY

Header Beam Reactions to Booms for Rated Capacity Cask...

Horizontal Forces due to Dynamic Loads and Road Slopes; Cask Restrained;
Only 50% of Total Forces are Header Beam Reactions to Boom:

Lateral Load	6,990 pounds
Longitudinal Load	13,480 pounds

Horizontal Forces due to Road Slopes and Wind; Cask Unrestrained:

Lateral Load	8,686 pounds
Longitudinal Load	21,611 pounds

Controlling Loads used for Design:

Vertical Load	213,924 pounds
Lateral Load	8,686 pounds
Longitudinal Load	21,611 pounds

Note on Design Load Assumptions:

Header Beam Longitudinal Load 1 is 50% of the load due to the combined dynamic longitudinal load of 2.50%, road grade force due to a maximum grade of 10.00%, and wind force due to a wind speed of 35 mph. This is based on the cask being secured in the travel position by the Restraint Strap with the total longitudinal force shared nominally equally between the Header Beam and Restraint Strap.

Header Beam Longitudinal Load 2 is the total road grade force due to a maximum grade of 10.00% and a wind force due to a wind speed of 35 mph. This models the possibility of having to release the cask and set it down on the road as a result of a mechanical breakdown or other unplanned event that could force unloading of the Transporter at any point on the route.

The same philosophy is applied to develop the lateral loads shown above.

BOOM ANALYSIS

Vertical Loads...

Stage	Load, kips	Height *, feet
Fully Retracted		16.91
Maximum Extension with Cask	213.92	21.59

Horizontal Loads...

Lateral Load	8.69 kips
Longitudinal Load	21.61 kips

Boom Geometry...

Section	Length, inches	Min. O/L, c-c pads, inches	% O/L	Section Stroke, inches
Base Section	115.875			
		25.000	28.4	
Power Section	88.000			56.186
Top Plate with Pivot	4.500			

Length of Upper Slider Pads	6.000	inches
Length of Lower Slider Pads	6.000	inches
CL Upper Pads to End of Section	3.000	inches
CL Lower Pads to End of Section	3.000	inches
Boom-to-Chassis Fixture Above GL	138.621	inches
Bottom of Base Section Above GL	82.496	inches

* Note: Height dimensions are to the CL of the Header Beam pivot pin.

BOOM ANALYSIS

Cantilever Length and Design Loads by Section

Base Section

Cantilever Length, feet	Mx, kip-inches	My, kip-inches	Compr., kips
10.04	2,602.81	1,046.12	213.92

Power Section

Cantilever Length, feet	Mx, kip-inches	My, kip-inches	Compr., kips	Slider Pad Forces in Overlap, kips			
				Longitudinal Lower	Longitudinal Upper	Lateral Lower	Lateral Upper
5.31	1,376.36	553.18	213.92	27.53	38.33	11.06	15.41

BOOM ANALYSIS

Base Section Analysis - 1 of 2

Section Dimensions...

Overall Depth (longitudinal direction)	20.625	inches
Overall Width (lateral direction)	19.250	inches
Flange Plate Thickness	0.375	inch
Web Plate Thickness	0.375	inch
Out-to-Out of Flanges	19.625	inches
Fy	50	ksi (ASTM A572 Grade 50)
Fu	65	ksi
Weld Size	5/16	inch
Filler Strength	70	ksi
Number of Sides Welded	2	

Section Weight...

Weight of Stiffeners, Pads, etc.	539	pounds
Weight of Box Section	931	pounds
Total Weight of Base Section	1,470	pounds

Geometry and Section Properties...

Flange Plate Clear Width	18.50	inches (= in-to-in of webs)
Web Plate Clear Depth	18.88	inches
Weight per Foot	99.85	lbs./foot
Gross Area	29.34	in.^2
Gross Ix	1,833.91	in.^4
Gross Iy	1,773.65	in.^4
rx	7.91	inches
ry	7.77	inches
Flange b/t	49.33	> 238/√Fy Use b e for Mx
		< 970/√Fy * ( ) O.K. for My
Web b/t	50.33	> 238/√Fy Use b e for My
		< 970/√Fy * ( ) O.K. for Mx
Effective Flange b	15.36	inches for computing Ix
	18.50	inches for computing Iy
Effective Web b	20.63	inches for computing Ix
	20.63	inches for computing Iy
Effective Area	26.99	in.^2
Effective Ix	1,615.59	in.^4
Effective Sx	156.66	in.^3
Effective Iy	1,773.65	in.^4
Effective Sy	184.28	in.^3

Bending and Axial Stress Calculations...

fbx (due to longitudinal force)	16.61	ksi
fby (due to lateral force)	5.68	ksi
fa (due to compression)	7.29	ksi
Fa	25.67	ksi
Fb	30.00	ksi
Axial + Bending S.R.	**0.98 ≤ 1.00**	**O.K.**

BOOM ANALYSIS

Base Section Analysis - 2 of 2

Shear Stress Calculations...

Vx	76.67 kips
fvx	4.96 ksi
Fvx	20.00 ksi
Shear S.R.	**0.25 ≤ 1.00 O.K.**
Vy	30.81 kips
fvy	2.13 ksi
Fvy	20.00 ksi
Shear S.R.	**0.11 ≤ 1.00 O.K.**

Weld Design...

Power Section Lower Pad Force	29.67 kips (combined long. and lat.)
Slider Pad Force v	1.35 kips per inch per weld
Section Horizontal Shear v	2.95 kips per inch per weld
Total Weld v	3.24 kips per inch per weld
Weld V	4.64 kips per inch per weld
Weld S.R.	**0.70 ≤ 1.00 O.K.**

Base Section Maximum S.R. **0.98 ≤ 1.00 O.K.**

BOOM ANALYSIS

Power Section Analysis - 1 of 2

Section Dimensions...

Overall Depth (Long. direction)	17.875	inches
Overall Width (Lat. direction)	16.500	inches
Flange Plate Thickness	0.500	inch
Web Plate Thickness	0.500	inch
Out-to-Out of Flanges	16.875	inches
Fy	50	ksi (ASTM A572 Grade 50)
Fu	65	ksi
Weld Size	3/8	inch
Filler Strength	70	ksi
Number of Sides Welded Along Length	1	
Number of Sides Welded at Ends	2	

Section Weight...

Weight of Stiffeners, Pads, etc.	427	pounds
Weight of Box Section	823	pounds
Total Weight of Power Section	1,250	pounds

Geometry and Section Properties...

Flange Plate Clear Width	15.50	inches (= in-to-in of webs)
Web Plate Clear Depth	16.88	inches
Weight per Foot	113.57	lbs./foot
Gross Area	33.38	in.^2
Gross Ix	1,515.31	in.^4
Gross Iy	1,454.70	in.^4
rx	6.74	inches
ry	6.60	inches
Flange b/t	31.00	< 238/√Fy O.K. for Mx
		< 970/√Fy * ( ) O.K. for My
Web b/t	33.75	> 238/√Fy Use b e for My
		< 970/√Fy * ( ) O.K. for Mx
Effective Flange b	15.50	inches for computing Ix
	15.50	inches for computing Iy
Effective Web b	17.88	inches for computing Ix
	17.88	inches for computing Iy
Effective Area	33.38	in.^2
Effective Ix	1,515.31	in.^4
Effective Sx	169.55	in.^3
Effective Iy	1,454.70	in.^4
Effective Sy	176.33	in.^3

Bending and Axial Stress Calculations...

fbx (due to longitudinal force)	8.12	ksi
fby (due to lateral force)	3.14	ksi
fa (due to compression)	6.41	ksi
Fa	26.91	ksi
Fb	30.00	ksi
Axial + Bending S.R.	**0.59**	**≤ 1.00 O.K.**

BOOM ANALYSIS

Power Section Analysis - 2 of 2

Shear Stress Calculations...

Vx	55.05	kips
fvx	3.08	ksi
Fvx	20.00	ksi
Shear S.R.	**0.15 ≤ 1.00**	**O.K.**
Vy	22.13	kips
fvy	1.34	ksi
Fvy	20.00	ksi
Shear S.R.	**0.07 ≤ 1.00**	**O.K.**

Slider Pad Web Stress Analysis...

Slider Pad Forces:

Force at Lower Pad to Web	27.53 kips
Force at Upper Pad to Web	38.33 kips
Force at Lower Pad to Flange	11.06 kips
Force at Upper Pad to Flange	15.41 kips

Web Compression at Lower Pad:

J10-3 Ra	136.46 kips
J10-3 S.R.	**0.20 ≤ 1.00 O.K.**
J10-5 Ra	129.01 kips
J10-5 S.R.	**0.21 ≤ 1.00 O.K.**

Web Compression at Upper Pad:

J10-2 Ra	172.92 kips
J10-2 S.R.	**0.22 ≤ 1.00 O.K.**
J10-4 Ra	241.67 kips
J10-4 S.R.	**0.16 ≤ 1.00 O.K.**

Flange Compression at Lower Pad:

J10-3 Ra	136.46 kips
J10-3 S.R.	**0.08 ≤ 1.00 O.K.**
J10-5 Ra	135.74 kips
J10-5 S.R.	**0.08 ≤ 1.00 O.K.**

Flange Compression at Upper Pad:

J10-2 Ra	172.92 kips
J10-2 S.R.	**0.09 ≤ 1.00 O.K.**
J10-4 Ra	251.78 kips
J10-4 S.R.	**0.06 ≤ 1.00 O.K.**

Weld Design...

Maximum Lower Slider Pad Force v	1.98 kips per inch per weld
Maximum Upper Slider Pad Force v	4.59 kips per inch per weld
Section Horizontal Shear v	2.85 kips per inch per weld
Total Weld v	5.40 kips per inch per weld
Weld V	5.57 kips per inch per weld
Weld S.R.	**0.97 ≤ 1.00 O.K.**

Power Section Maximum S.R. **0.97 ≤ 1.00 O.K.**

BOOM ANALYSIS

Summary of Section Component Sizes

Section	Overall Depth	Overall Width	Flange PL Thickness	Web PL Thickness	Flange PL Width	Web PL Width
Base	20.625	19.250	0.375	0.375	18.500	20.625
Power	17.875	16.500	0.500	0.500	15.500	17.875

Section Welding

Section	Size	Electrodes
Base	5/16 both sides	E70xx
Power	3/8 outside + ends	E70xx

Notes: All welding is continuous fillet welding. Welding is either outside only or inside and outside, as indicated.

Section Clearances (without slider pads)

Location	Longitudinal	Lateral
Base to Power	2.000	2.000

Note: Longitudinal clearance is from inside face of outer section flange to outside face of inner section flange.
Lateral clearance is from inside face of outer section web to outside face of inner section web.
Clearances are total, not per side.

VERTICAL DIMENSION SUMMARY

GL to Header Beam Pivot Pin - Fully Retracted	202.872	inches
GL to Header Beam Pivot Pin - Fully Extended	259.058	inches
Height of Header Beam Pivot Lugs	3.750	inches
Header Beam Depth	20.000	inches
Thickness of Side Shift Plate and Slider Pads	1.500	inches
Lift Link Top Bar Depth	6.500	inches
Overall Height - Booms Fully Retracted	234.622	inches
Overall Height - Booms Fully Extended	290.808	inches
Cask Bottom Clearance with Booms Extended	24.000	inches
Cask Bottom Clearance at Normal Travel Height	11.000	inches
Overall Height at Normal Travel Height	277.808	inches

BOOM ANALYSIS

Boom Lateral Displacements due to Clearances

Design Clearances...

Base to Power 0.050 inch

Design Vertical Lengths...

Location	Point No.	Length, inches
Bottom of Power	1	170.371
Top of Base	2	25.000
Top of Power	3	60.000
Header Plate	4	4.500
Sum of the Lengths		259.871

You have an error in the boom section length dimensions.

Section Angles...

Section	Angle, degrees
Base Section	0.000
Power Section	0.115

Lateral Displacements...

Point	Displ.
2	0.000 inch
4	0.154 inch

Drift Limits...

Total Drift	0.154 inch
Allowable Drift	0.780 inch
Status	**O.K.**
Power Section Drift	0.154 inch
Power Section Length	60.000 inches
Allowable Drift	0.360 inch
Status	**O.K.**

BOOM ANALYSIS

Boom Deflection due to Longitudinal Force

Longitudinal Force	21.61	kips
Moment Applied at Base/Power Overlap	1,664.07	kip-inches
Base L	44.25	inches
Base Ix	1,833.91	in.^4
Deflection at Top of Base	0.0424	inch
Rotation at Top of Base	0.0018	radian
Moment Applied at Top of Power Section	0.00	kip-inches
Power Section L	77.00	inches
Power Section Ix	1,515.31	in.^4
Deflection at Top of Power Section	0.2545	inch
Rotation at Top of Power Section	0.0032	radian

Boom Deflection due to Lateral Force

Lateral Force	8.69	kips
Moment Applied at Base/Power Overlap	668.82	kip-inches
Base L	44.25	inches
Base Iy	1,773.65	in.^4
Deflection at Top of Base	0.0176	inch
Rotation at Top of Base	0.0007	radian
Moment Applied at Top of Power Section	0.00	kip-inches
Power Section L	77.00	inches
Power Section Iy	1,454.70	in.^4
Deflection at Top of Power Section	0.1060	inch
Rotation at Top of Power Section	0.0014	radian

BOOM ANALYSIS

Wedge-Lock Loads and Dimensions...

Total Load per Leg	215.17	kips
Number of Wedges	4	
Wedge Face Height	4.000	inches
Wedge Face Width	2.438	inches
Ramp Angle from Horizontal	71.000	degrees
Wedge-Ramp Coefficient of Friction	0.250	(lubricated steel-on-steel)
Flange or Web Compressed?	Flange	
Power Section Overall Width	16.500	inches
Power Section Flange Out-to-Out	16.875	inches
Base Section Flange Out-to-Out	19.625	inches
Power Section Flange Plate Thickness	0.500	inch
Power Section Web Plate Thickness	0.500	inch
Web-to-Flange Fillet Weld Size	3/8	inch
Power Section Fy	50	ksi (ASTM A572 Grade 50)

Wedge Free-Body Forces...

Inside Tangential Force = P	53.79	kips
Inside Normal Force = N	82.72	kips
Ramp Tangential Force = F	23.93	kips
Ramp Normal Force = R	95.73	kips

Friction Calculations...

P / N	0.65	
Assumed Ramp Coefficient	0.25 < 0.65	O.K.

Power Section Web Buckling...

Normal Load to Plate	82.72	kips
Compressed Plate Thickness	0.500	inch
Perpendicular Plate Thickness	0.500	inch
Allowable Load by Plate Yielding	139.58	kips
J10-2 S.R.	**0.59 ≤ 1.00**	**O.K.**
Plate Crippling Load	82.72	kips
Depth in Direction of Compression	16.500	inches
Allowable Load	207.99	kips
J10-4 S.R.	**0.40 ≤ 1.00**	**O.K.**
Clear Plate Depth, h	15.50	inches
h/tw	31.00	
Compression Force	82.72	kips
Allowable Plate Compression	139.84	kips
J10-8 S.R.	**0.59 ≤ 1.00**	**O.K.**

Bearing Stress...

Inside Bearing Stress	8.48	ksi
Allowable Bearing Stress	45.00	ksi
J7 S.R.	**0.19 ≤ 1.00**	**O.K.**

BOOM ANALYSIS

Wedge-Lock Collar Dimensions...

Net Width of Collar Tension Plates	2.125	inches
Upper Collar Tension Plate Thickness	0.750	inch
Lower Collar Tension Plate Thickness	0.750	inch
Base Section Flange Plate Effective Width	8.500	inches
Wedge Spacing, c-c	15.125	inches
Collar Main Plate Width	6.000	inches
Depth of Wedge Cut-Out	2.063	inches
Upper Collar Main Plate Thickness	0.750	inch
Lower Collar Main Plate Thickness	0.750	inch
Base Section Web Plate Effective Width	8.500	inches
Collar Plates Fy	50	ksi (ASTM A572 Grade 50)

Out-to-Out of Collar Tension Plates	20.750	inches
Net Width of Collar Tension Plates	2.1250	inches
Force per Wedge	82.72	kips

Wedge-Lock Collar System Analysis...

Tension Plate Load	82.72	kips
Composite Area	6.38	in.^2
ft	12.98	ksi
Ft	30.00	ksi
Tension Plate S.R.	**0.43 ≤ 1.00**	**O.K.**
Main Plate Moment Arm	1.75	inches
Main Plate Moment	144.76	kip-inches
Composite Area	9.09	in.^2
Composite y bar	2.93	inches
Composite c	3.45	inches
Composite Ix	44.51	in.^4
Composite Sx	12.91	in.^3
fb	11.21	ksi
Fb	30.00	ksi
Main Plate S.R.	**0.37 ≤ 1.00**	**O.K.**
Cross-Corner Main Plate Moment	262.32	kip-inches
fb	20.32	ksi
Fy	50.00	ksi
Main Plate S.R.	**0.41 ≤ 1.00**	**O.K.**

BOOM ANALYSIS

Header Plate Fixture

Geometry and Loads...

Vertical Reaction	213.92	kips
Lateral Reaction	8.69	kips
Resultant Load to Pin	214.10	kips
Lower Plate Thickness	1.500	inches
Lower Plate Span	16.375	inches
Lower Lug Plate Thickness	2.000	inches
Lower Lug Plate Width at Base	12.000	inches
Lower Lug Plate Spacing in-to-in	9.250	inches
Lower Lug Plate Hole Height	3.000	inches
Upper Lug Plate Thickness	2.000	inches
Upper Lug Plate Spacing out-to-out	9.000	inches
Upper Lug Plate Hole Height	3.000	inches
Lower Plate Fy	100	ksi (ASTM A514)
Lug Plate Fy	50	ksi (ASTM A572 Grade 50)
Pin Diameter	3.480	inches
Pin Fy	105	ksi (ASTM A564 Type 630 H1150)

Lower Plate Analysis...

Moment	274.09	kip-inches
Sx	7.31	in.^3
fb	37.48	ksi
Fb	60.00	ksi
Bending S.R.	**0.62 ≤ 1.00**	**O.K.**

Pin Stress Analysis...

Shear Area	9.51	in.^2
Maximum Shear	107.05	kips
fv	11.25	ksi
Fv	42.00	ksi
Shear S.R.	**0.27 ≤ 1.00**	**O.K.**
Section Modulus	4.14	in.^3
Maximum Moment	227.48	kip-inches
fb	54.98	ksi
Fb	100.60	ksi
Bending S.R.	**0.55 ≤ 1.00**	**O.K.**
Minimum Bearing Area	13.92	in.^2
Bearing Force	214.10	kips
fp	15.38	ksi
Fp	45.00	ksi
Bearing S.R.	**0.34 ≤ 1.00**	**O.K.**

BOOM ANALYSIS

Inside Cylinder Support Plates

Geometry and Loading...

Number of Plates	2	
Clear Between Plates	3.250	inches
Plate Thickness	2.000	inches
Plate Depth	9.000	inches
Hole Diameter	3.515	inches
CL Hole from Bottom	4.500	inches
Support Plates Fy	50	ksi (ASTM A572 Grade 50)
Minimum Weld Size	5/16	inch
Filler Strength	70	ksi

Plate Span	19.625	inches (out-to-out of flanges)
Pin Load	215.77	kips (at rated capacity)
Boom Section Flange Thickness	0.375	inch
Boom Section Flange Fu	65.00	ksi

Section Properties...

Area	10.970	in.^2
y bar	4.500	inches
c	4.500	inches
Ix	114.262	in.^4
Sx	25.392	in.^3

Member Forces and Stresses...

Support Plate Moment on CL	529.32	kip-inches
fb	20.85	ksi
Support Plate Moment at Hole Shear Plane	462.28	kip-inches
fb	18.21	ksi
Pin Hole fv	8.28	ksi
Pin Hole Critical Stress	23.18	ksi
Fb	30.00	ksi
Bending S.R.	**0.77 ≤ 1.00**	**O.K.**
Support Plate Shear	53.94	kips
fv	3.00	ksi
Fv	20.00	ksi
Shear S.R.	**0.15 ≤ 1.00**	**O.K.**
Support Plate-to-Boom Flange Weld v	3.00	kips per inch (weld 2 sides)
Weld V	4.64	kips per inch
Weld S.R.	**0.65 ≤ 1.00**	**O.K.**
Boom Flange Strength	219.98	ksi
Boom Section Flange S.R.	**0.49 ≤ 1.00**	**O.K.**

BOOM ANALYSIS

Inside Cylinder Pin Design

Configuration and Loading...

Pin Load	215.77	kips
Support Plate Thickness	2.000	inches
Clear Between Support Plates	3.250	inches
Thickness of Cylinder Clevis Lugs	2.625	inches
Pin Diameter	3.490	inches
Pin Fy	113	ksi (AISI 4140 HR HT)
Plate Fy	50	ksi (ASTM A572 Grade 50)

Pin Loads...

Support Plate Load	107.89	kips each
Cylinder Lug Load	215.77	kips
Maximum Shear	107.89	kips
Maximum Moment	212.40	kip-inches

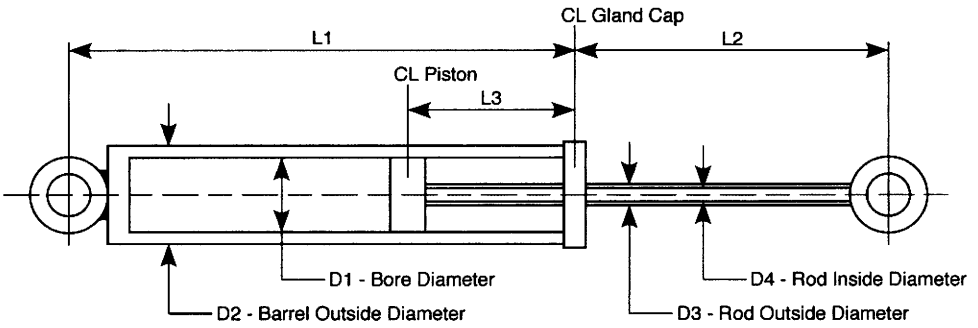
Pin Stress Analysis...

Shear Area	9.57	in.^2
fv	11.28	ksi
Fv	45.20	ksi
Shear S.R.	**0.25 ≤ 1.00**	**O.K.**
Section Modulus	4.17	in.^3
fb	50.90	ksi
Fb	108.26	ksi
Bending S.R.	**0.47 ≤ 1.00**	**O.K.**
Support Plate Bearing Area	13.96	in.^2
Cylinder Clevis Bearing Area	9.16	in.^2
fp	23.55	ksi
Fp	45.00	ksi
Bearing S.R.	**0.52 ≤ 1.00**	**O.K.**

BOOM ANALYSIS

Extend Cylinder Dimensions and Properties...

Barrel O.D., D2	12.500	inches
Barrel I.D., D1	11.500	inches
Rod O.D., D3	6.000	inches
Rod I.D.	5.000	inches
Effective Length of Barrel, L1	82.750	inches
Effective Length of Rod, L2	82.250	inches
Overlap, L3	5.750	inches
Barrel Yield Stress, Fy	75	ksi (AISI 1026 DOM)
Modulus of Elasticity, E1 and E2	29,000	ksi
Operating Pressure	2,800	psi
Cylinder Test Pressure (maximum)	3,000	psi (off-vehicle test)
Cylinder Design Load	188.49	kips (vertical impact excluded)
Cylinder Test Load	235.61	kips (125% of loads; no impact)



Dimension Notation

Cylinder Properties and Intermediate Values...

Moment of Inertia of Barrel, I1	339.881	in.^4	J1	135.457
Moment of Inertia of Rod, I2	32.938	in.^4	J2	42.168
K1	119,112		B1	1.026
K2	11,613		B2	1.402
K3	166,120			

Final Results...

Critical Buckling Load, PC	537.18	kips
Allowable Axial Load	268.59	kips
Buckling S.R.	**0.70 ≤ 1.00**	**O.K.**
Internal Pressure, Operating	1,815	psi
Allowable Pressure	2,800	psi
Operating Pressure S.R.	**0.65 ≤ 1.00**	**O.K.**
Internal Pressure, Test	2,268	psi
Allowable Pressure	3,000	psi
Test Pressure S.R.	**0.76 ≤ 1.00**	**O.K.**
Hoop Tensile Stress at 2,800 psi	32.20	ksi
Allowable Hoop Tensile Stress	37.50	ksi
Hoop Tension S.R.	**0.86 ≤ 1.00**	**O.K.**

Cylinder Weight...

Cylinder Dead Weight with End Pins	600	pounds

BASE FRAME

Configuration and Loads...

Vertical Load	217.24	kips
Lateral Load	8.69	kips
Longitudinal Load	21.61	kips
Maximum Boom Height Above Chassis	177.56	inches
Top of Chassis Above Ground	81.496	inches
Side Plate Thickness	0.500	inch
Side Plate Spacing, in-to-in	19.250	inches
End Plate Thickness	0.500	inch
Edge of Side Plate to End Plate CL	3.750	inches
Width of Opening in End Plate	14.000	inches
Height of Opening in End Plate	18.000	inches
Bottom of Opening to Bottom of Plate	17.344	inches
Spread of Bottom of End Plates	82.125	inches
Spread of Top of End Plates	19.875	inches
Top of End Plates Above Chassis	57.125	inches
Bottom of End Plates Above Chassis	2.750	inches
End Plate Angle (from horizontal)	60.21	degrees
Fy	50	ksi (ASTM A572 Grade 50)
Longitudinal Bolt Group Spacing	87.500	inches
Lateral Bolt Group Width	11.625	inches
Bolt Diameter	1.000	inch
Bolt Grade	ASTM A325	
Allowable Tension Load	35.30	kips
Allowable Shear Load	18.80	kips

Plate Corner Analysis...

End Plate Width at Side of Opening	2.63	inches
Eff. Width of Side Plate at Corner	10.00	inches = overhang + 12.5 t
Area of One Corner	6.31	in.^2
x bar	4.74	inches
y bar	0.57	inch
Iy	3.40	in.^4
ry	0.73	inch
Longitudinal Spread at Top of Opening	38.78	inches
Lateral Spread at Top of Opening	19.10	inches
Top of Opening Above Chassis	33.42	inches
fa due to Vertical Load	9.91	ksi
fa due to Lateral Load	5.98	ksi
fa due to Longitudinal Load	7.33	ksi
Maximum Stress	23.23	ksi
Minimum Stress	-3.40	ksi
Maximum fa at Top of Opening	23.23	ksi
Kl/r	24.54	
Cc	107.00	ksi
Fa	27.80	ksi
Corner S.R.	**0.84 ≤ 1.00**	**O.K.**

BASE FRAME

Bolt Group Analysis...

Assume only the four corner bolts are 100% effective.

Maximum Bolt Tension	16.77	kips
Maximum Bolt Shear	5.82	kips
Allowable Tension	33.12	kips
Tension S.R.	**0.51 ≤ 1.00**	**O.K.**
Allowable Shear	18.80	kips
Shear S.R.	**0.31 ≤ 1.00**	**O.K.**

Base Frame Weight...

Base Frame Dead Weight	1,590	pounds

Summary of Base Frame Reactions to Chassis...

Maximum Vertical Load	218.83	kips
Maximum Lateral Load	8.69	kips (cask unrestrained)
Maximum Longitudinal Load	21.61	kips (cask unrestrained)
Total Vertical Load	433.29	kips
Total Lateral Load	17.37	kips (cask unrestrained)
Total Longitudinal Load	42.78	kips (cask unrestrained)
Maximum Boom Height Above Chassis	177.562	inches
Base Frame Bolt Group Length	87.500	inches
Base Frame Bolt Group Width	11.625	inches
Total Dead Weight of Upper	19,289	pounds
Maximum Non-factored Vertical Load	190,562	pounds at 1.00" side shift
=	188,667	pounds with cask centered

TRANSFER CASK LINKS AND PINS

Design Basis...

Transfer Cask Weight	55	tons
Cask Trunnion Outside Diameter	10.000	inches

Allowable Stresses...

Allowable Shear Stress	0.40	Fy (SAE J1078)
Allowable Bending Stress for Round Pins	0.96	Fy [AISC F11.1 (not addressed in J1078)]
Allowable Tension Stress	0.60	Fy (SAE J1078)
Allowable Bearing Stress for Round Pins	0.90	Fy [AISC J7 (not addressed in J1078)]
Nominal Design Factor	1.67	

Cask Link Load...

Design Load at Lower Hole	55,000 pounds
Design Load at Upper Hole	55,116 pounds

Cask Link Dimensions...

Pin Diameter	3.000 inches
Upper Hole Diameter	3.063 inches
Upper Hole End Radius	4.000 inches
Upper Hole Side Radius	4.188 inches
Lower Section Outside Radius	8.500 inches
Lower Section Inside Radius	5.063 inches
Minimum Net Width at Lower Hole	1.688 inches
Thickness	2.000 inches
CL Upper Hole to CL Lower Hole	15.000 inches
Steel Grade	ASTM A36
Fy	36 ksi
Fu	58 ksi
Cask Link Weight	116 pounds

Upper Hole Analysis...

Dp / Dh	0.98
Cr	0.94
Phi	53.88 degrees
Main Plate be	2.656 inches
Main Plate b eff	2.656 inches
Main Plate a	2.469 inches
Main Plate Z - Z'	2.897 inches
Net Section Pt	291.09 kips
Beyond Hole Splitting Pb	224.57 kips
Beyond Hole Shear Pv	235.20 kips
Bearing Pp	162.00 kips
Allowable Load at Upper Pin Hole	162.00 kips
Upper Hole S.R.	**0.34 ≤ 1.00 O.K.**

Lower Hole Analysis...

Net Body Area	3.38 in.^2 each side
Angle of Side Bars	16.04 degrees from vertical
Tension in Side Bar	28.61 kips
ft	8.48 ksi
Ft	21.60 ksi
Lower Hole S.R.	**0.39 ≤ 1.00 O.K.**
Lower Hole Dp / Dh	0.99 ≥ 0.90 O.K.

Lift Link Adapter Pin Load

Design Load	55,116	pounds

Pin Dimensions and Configuration...

Pin Diameter	3.000	inches
Steel Grade	ASTM A311	
Fy	100	ksi
Fu	115	ksi
Pin Weight	11	pounds
Cask Link Thickness	2.000	inches
Adapter Tang Thickness	1.375	inches
Clear Between Adapter Tangs	2.250	inches

Pin Stress Analysis...

Shear Area	7.07	in.^2
Maximum Shear	27.56	kips
fv	3.90	ksi
Fv	40.00	ksi
Shear S.R.	**0.10 ≤ 1.00**	**O.K.**
Section Modulus	2.65	in.^3
Maximum Moment	36.17	kip-inches
fb	13.65	ksi
Fb	95.81	ksi
Bending S.R.	**0.14 ≤ 1.00**	**O.K.**
Minimum Bearing Area	6.00	in.^2
Bearing Force	55.12	kips
fp	9.19	ksi
Fp	90.00	ksi
Bearing S.R.	**0.10 ≤ 1.00**	**O.K.**

Lift Link Adapter Lower Hole Load...

Design Load	55,127	pounds

Lower Hole Dimensions...

Pin Diameter	3.000	inches
Hole Diameter	3.063	inches
End Radius	4.000	inches
Side Radius	4.000	inches
Thickness	1.375	inches
Clear Between Tangs	2.250	inches
Steel Grade	ASTM A36	
Fy	32	ksi
Fu	58	ksi
Lift Link Adapter Weight	205	pounds

Lower Hole Analysis...

Dp / Dh	0.98	
Cr	0.94	
Phi	53.88	degrees
Main Plate be	2.469	inches
Main Plate b eff	2.469	inches
Main Plate a	2.469	inches
Main Plate Z - Z'	2.897	inches
Net Section Pt	186.00	kips
Beyond Hole Splitting Pb	152.46	kips
Beyond Hole Shear Pv	161.70	kips
Bearing Pp	99.00	kips
Allowable Load at Pin Hole	99.00	kips each tang
Lower Hole S.R.	**0.28 ≤ 1.00**	**O.K.**

Lift Link Adapter Upper Hole Load...

Design Load	55,332	pounds

Upper Hole Dimensions...

Pin Diameter	4.000	inches
Hole Diameter	4.125	inches
End Radius	4.000	inches
Side Radius	4.000	inches
Thickness	2.000	inches
Clear Between Tangs	4.000	inches
Steel Grade	ASTM A36	
Fy	32	ksi
Fu	58	ksi

Upper Hole Analysis...

Dp / Dh	0.97	
Cr	0.93	
Phi	53.33	degrees
Main Plate be	1.938	inches
Main Plate b eff	1.938	inches
Main Plate a	1.938	inches
Main Plate Z - Z'	2.407	inches
Net Section Pt	209.65	kips
Beyond Hole Splitting Pb	184.07	kips
Beyond Hole Shear Pv	195.48	kips
Bearing Pp	192.00	kips
Allowable Load at Pin Hole	184.07	kips each tang
Upper Hole S.R.	**0.15 ≤ 1.00**	**O.K.**

Load to Transporter Lift Link Pins...

Load to Lift Link Pins	55,332	pounds per pin
Pin Design Load	207,000	pounds per pin

Transfer Cask function is less severe than design transport function

CHASSIS

Maximum Loads From Base Frames...

Maximum Vertical Load	218.83	kips
Maximum Lateral Load	8.69	kips (accounts for 4.00% s/e)
Maximum Longitudinal Load	21.61	kips (accounts for 10.00% grade)
Maximum Boom Height Above Chassis	177.562	inches
Base Frame Bolt Group Length	87.500	inches
Base Frame Bolt Group Width	11.625	inches
Base Frame Side Plate Spacing, c-c	19.750	inches
Total Vertical Load	433.29	kips
Total Lateral Load	17.37	kips (accounts for 4.00% s/e)
Total Longitudinal Load	42.78	kips (accounts for 10.00% grade)

Main Chassis Dimensions...

Crawler Bolt Group Spacing	123.622	inches
Rear Crawler Bolt Group to CL Booms	51.055	inches
Rear of Chassis to CL Booms	146.500	inches
Track Width	190.000	inches
Jack Mounting Pad Spacing, c-c	84.250	inches
Top of Chassis Above Ground	81.496	inches

Vertical Dimensions Used for Calculations...

Maximum Boom Height Above Chassis	177.562	inches
Top of Chassis Above Ground	81.496	inches
Crawler Track Rolling Radius	22.222	inches

Allowable Stresses - Chassis...

Allowable Shear Stress	0.40	Fy (SAE J1078)
Maximum Allowable Bending Stress	0.60	Fy (SAE J1078)
Allowable Bending Stress (flats)	0.90	Fy [AISC F11.1 (not addressed in J1078)]
Allowable Tension Stress	0.60	Fy (SAE J1078)
Allowable Column Buckling Stress	variable	Fy (SAE J1078)
Allowable Bearing Stress	0.90	Fy [AISC J7 (not addressed in J1078)]
Allowable Cylinder Hoop Stress	0.50	Fy (ASME B30.1-2009)
Allowable Cylinder Axial Load	0.50	Pcr (ASME B30.1-2009)
Cask Restraint System Load Factor	10.00%	(Lift Systems design standard)

Loads and Allowable Stresses - Tow Eye...

Allowable Shear Stress	0.40	Fy (SAE J1078)
Allowable Bending Stress (members)	0.60	Fy (SAE J1078)
Allowable Bending Stress (pins)	0.96	Fy [AISC F11.1 (not addressed in J1078)]
Allowable Tension Stress	0.60	Fy (SAE J1078)
Allowable Bearing Stress	0.90	Fy [AISC J7 (not addressed in J1078)]
Road Grade for Towing	10.00%	(ESS-018 §3.)

CHASSIS

Crawler Sideframe Product Information...

Manufacturer	Intertractor America Corp.	
Model	WWC011102	
Dead Weight (each)	36,400	pounds (w/ motor & final drive)
Mounting Bolt Group Spacing, c-c	123.62	inches
Bolt Group Length	41.73	inches
CL Mounting Bolt Group to Ground	29.02	inches
CL Rear Bolt Group to CL Track Brg.	46.44	inches
Track Rolling Radius	22.22	inches
Length Between Tumblers, c-c	197.20	inches
Track Pad Width	29.53	inches
Drive Sprocket Efficiency, *Et*	80%	
Drive Sprocket Pitch Diameter	44.445	inches
Powered Rolling Resistance	5%	
Unpowered Rolling Resistance	10%	

Final Drive Manufacturer	O & K Antriebstechnik GmbH	
Model	F360	
Reduction Ratio	223	:1
Final Drive Efficiency, *Et*	94%	

Hydraulic Motor Manufacturer	Mannesmann Rexroth	
Model	A2FE355	
Displacement, Δ	355	cm^3
Maximum Output Shaft Speed, *n max*	2,240	rpm
Flow at Maximum Speed, *Qmax*	795	liters per minute
Torque Constant, *Tk*	5.645	N-m/bar
Volumetric Efficiency, *Ev*	89%	at maximum speed
Volumetric Efficiency, *Ev*	24%	at maximum power
Mechanical-Hydraulic Efficiency, *Et*	50%	at maximum speed
Mechanical-Hydraulic Efficiency, *Et*	80%	at maximum power

Hydraulic Pump Product Information...

Final Drive Manufacturer	Sauer Sundstrand	
Model	90R250EA	
Dead Weight	340	pounds
Maximum Displacement, Δ	250	cm^3 (for top speed)
=	15.26	in.^3
...at a Swash Angle of	17.00	degrees
Minimum Displacement, Δ	32	cm^3 (for maximum drawbar pull)
=	1.94	in.^3
...at a Swash Angle of	2.07	degrees
Rated Output Pressure	6,000	psi
Maximum Input Shaft Speed	2,500	rpm
Volumetric Efficiency, *Ev*	88%	at swash angle = 17.00 degrees
Volumetric Efficiency, *Ev*	15%	at swash angle = 2.07 degrees
Mechanical-Hydraulic Efficiency, *Et*	80%	at swash angle = 17.00 degrees
Mechanical-Hydraulic Efficiency, *Et*	70%	at swash angle = 2.07 degrees

CHASSIS

Engine Product Information...

Engine Manufacturer	Cummins Engine Co., Inc.	
Model	D313001CX03	
Dead Weight	2,400	pounds
Maximum Continuous Output Speed	2,500	rpm
Power at Maximum Speed	275	horsepower
Maximum Torque	730	foot-pounds
Output Speed at Maximum Torque	1,500	rpm
Power at Maximum Torque	208	horsepower
Number of Pumps Driven by Engine	2	
Gear Reducer Manufacturer	Durst	
Model	KFO1	
Reduction Ratio	1.68	:1
Reducer Efficiency	94%	

CHASSIS HYDRAULIC DRIVE SYSTEM

Pump Evaluation...

Maximum Shaft Speed	1,488	rpm
Shaft Input Power	121	net horsepower per pump
Maximum Pump Output Flow, *Fp*	86.48	gpm
=	327.38	liters per minute
Pump Output Pressure, *Pp*	1,695	psi
=	116.92	bar
Maximum Shaft Speed	1,488	rpm
Shaft Input Power	121	net horsepower per pump
Pump Output Flow, *Fp*	1.87	gpm
=	7.08	liters per minute
Maximum Pump Output Pressure, *Pp*	11,690	psi
=	806.21	bar

Motor Evaluation...

Maximum Input Flow	327.38	liters per minute
Input Pressure	116.92	bar
Maximum Output Shaft Speed	821	rpm
Output Shaft Torque, *Tm*	330.02	N-m
=	243.41	foot-pounds
Maximum Input Pressure	806.21	bar
Input Flow	7.08	liters per minute
Maximum Output Shaft Speed	5	rpm
Maximum Output Shaft Torque, *Tm*	3,640.84	N-m
=	2,685.34	foot-pounds

Final Drive Evaluation...

Maximum Input Speed	821	rpm
Input Torque	243.41	foot-pounds
Maximum Output Speed	3.68	rpm
Output Torque, *Tfd*	51,024	foot-pounds
Maximum Input Torque	2,685.34	foot-pounds
Input Speed	5	rpm
Output Speed	0.02	rpm
Maximum Output Torque, *Tfd*	562,902	foot-pounds

Crawler Sideframe Evaluation...

Maximum Input Speed	3.68	rpm
Input Torque	51,024	foot-pounds
Maximum Travel Speed	42.84	feet per minute
=	**0.49**	**mile per hour**
Drawbar Pull, *DP*	22,042	pounds per crawler
Maximum Input Torque	562,902	foot-pounds
Input Speed	0.02	rpm
Travel Speed	0.25	feet per minute
=	0.003	mile per hour
Maximum Drawbar Pull, *DP*	**243,171**	**pounds per crawler**

CHASSIS HYDRAULIC DRIVE SYSTEM

Turning Forces...

Drawbar Pull from One Crawler	243.17	kips
Crawler Spacing, c-c	190.00	inches
Steering Moment	46,203	kip-inches
Mounting Bolt Group Spacing, c-c	123.62	inches
Lateral Force on Bolt Group Lines	373.74	kips based on full drawbar pull

Drawbar Force Evaluation...

Gross Vehicle Weight	511,464	pounds
Rolling Resistance	5.00%	
Rolling Resistance Force	25,573	pounds
Maximum Grade	10.00%	
Maximum Grade Force	51,146	pounds
Grade on Curve	10.00%	
Grade Force in Turn	51,146	pounds
Coefficient of Friction to Road	50.00%	
Load on Half of One Crawler	127,866	pounds
Friction Force	63,933	pounds
Friction Force Couple Length	197.20	inches
Skewing Couple	12,607,890	pound-inches
Crawler Spacing	190.000	inches
Skewing Force	66,357	pounds to one crawler

Case 1 - Transporter on Straight Road

Total Tractive Effort Required	76,720	pounds
Drawbar Pull Provided	486,343	pounds
Performance Ratio	**0.16 ≤ 1.00**	**O.K.**

Case 2 - Transporter in Turn

Rolling + Grade Resistances	76,720	pounds
=	38,360	pounds per crawler
Skewing Force	66,357	pounds at one crawler
Total Tractive Effort Required	104,717	pounds at one crawler
Drawbar Pull Provided	243,171	pounds at one crawler
Performance Ratio	**0.43 ≤ 1.00**	**O.K.**

CHASSIS SIDE FRAME

Dimensions and Loads...

Depth	16.000	inches
Web Thickness	0.375	inch
Web Spacing, out-to-out	36.500	inches
Flange Thickness	0.750	inch
Flange Width	38.000	inches
Fy	50	ksi (ASTM A572 Grade 50)
Web-to-Flange Weld Size	5/16	inch
Filler Strength	70	ksi
Web-to-Flange Weld Size at Pad	1/2	inch
Filler Strength	70	ksi
Number of Sides Welded	1	
Jack Mounting Pad Thickness	2.000	inches
Jack Mounting Pad Width	9.750	inches
Fy	50	ksi (ASTM A572 Grade 50)
Diaphragm Thickness	0.375	inch
Effective Width of Beam Flange under Pad	36.585	inches
Weld Size	5/16	inch
Filler Strength	70	ksi
Crawler Mount Side Plate Thickness	2.000	inches
Crawler Mount Side Plate Depth	46.000	inches
Access Hole Width	12.000	inches
Access Hole Height	10.750	inches
Bottom of Side Frame to Top of Hole	14.250	inches
Crawler Mount Side Plate Eff. Width	107.692	inches per bolt group
Plate Spacing, in-to-in	33.000	inches
Fy	55	ksi (ASTM A572 Grade 50 with special req.)
Top Stiffener Plate Thickness	1.000	inch
Top Stiffener Plate Width	92.000	inches
CL Stiffener to Bottom of Side Frame	3.500	inches
Fy	50	ksi (ASTM A572 Grade 50)
Weld Size	3/4	inch
Filler Strength	70	ksi
Number of Sides Welded	1	
Crawler Mount Bolt Grade	SAE Grade 5	
Bolt Diameter	1.000	inch
Allowable Tension Load	34.60	kips
Number of Bolts per Row	9	
Spacing Between Rows	10.63	inches
Shear Block Length	40.00	inches
Weld Size	3/8	inch
Filler Strength	70	ksi

CHASSIS SIDE FRAME

Dimensions and Loads (con't.)...

Load Distributed over Full Length of Crawlers:	
Front Bolt Group Load on Level Road	92.25 kips
Front Bolt Group Load When Downhill	133.65 kips
Front Bolt Group Load When Uphill	50.85 kips
Rear Bolt Group Load on Level Road	156.27 kips
Rear Bolt Group Load When Downhill	114.87 kips
Rear Bolt Group Load When Uphill	197.67 kips
Load Supported at Diagonally Opposite Corners:	
Front Bolt Group Load on Level Road	182.69 kips
Front Bolt Group Load When Downhill	264.65 kips
Front Bolt Group Load When Uphill	100.73 kips
Rear Bolt Group Load on Level Road	309.97 kips
Rear Bolt Group Load When Downhill	228.01 kips
Rear Bolt Group Load When Uphill	391.93 kips
Bolt Group Lateral Steering Load	373.74 kips
Maximum Pad-to-Web Point Load	98.83 kips
Minimum Pad-to-Web Point Load	10.59 kips
Average Pad-to-Web Point Load	54.71 kips
Maximum Base-to-Pad Point Load	116.53 kips

CHASSIS SIDE FRAME

Section Properties...

Shear Area	196.00	in.^2
Gross Area	251.88	in.^2
y bar (from top fiber)	30.65	inches
c	31.35	inches
Ix	83,602.90	in.^4
Sx	2,666.43	in.^3
Iy	66,818.47	in.^4
Sy	3,516.76	in.^3

Stress Analysis...

Maximum Shear	391.93	kips
fv due to Shear	2.00	ksi
Maximum Torsion	1,611.79	kip-inches
Sz	413.18	in.^3
fv due to Torsion	3.90	ksi
Fv	20.00	ksi
Shear S.R.	**0.30 ≤ 1.00**	**O.K.**

Case 1 - Uniform Crawler Bearing; Straight Travel:

Mx	10,092.25	kip-inches on CL
fbx	3.78	ksi
My	260.32	kip-inches on CL
fby	0.07	ksi
Fb	30.00	ksi
Case 1 Bending S.R.	**0.13 ≤ 1.00**	**O.K.**

Case 2 - Uniform Crawler Bearing; Turning:

Mx	0.00	kip-inches at Maximum My
fbx	0.00	ksi
My	55,618.93	kip-inches at Face of Center Section
fby	15.82	ksi
Fb	30.00	ksi
Case 2 Bending S.R.	**0.53 ≤ 1.00**	**O.K.**

Case 3 - Diagonal Point Bearing; Turning:

Mx	20,009.98	kip-inches on CL
fbx	7.50	ksi
My	260.32	kip-inches on CL
fby	0.07	ksi
Fb	30.00	ksi
Mx	22,698.44	kip-inches at Face of Center Section
fbx	8.51	ksi
My	55,618.93	kip-inches at Face of Center Section
fby	15.82	ksi
Fb	30.00	ksi
Case 3 Bending S.R.	**0.81 ≤ 1.00**	**O.K.**

fbx at Inside Fiber of Top Flange	8.12	ksi (compression)
Transv. fbx from Jack Mounting Pad	0.17	ksi (compression)
Critical Stress Under Jack Pad	8.03	ksi (Huber-vonMises formula)
Allowable Stress	30.00	ksi
Critical S.R.	**0.27 ≤ 1.00**	**O.K.**

Top Flange Weld v	2.02	kips per inch
Bottom Flange Weld v	2.60	kips per inch
Weld V	4.64	kips per inch
Weld S.R.	**0.56 ≤ 1.00**	**O.K.**

CHASSIS SIDE FRAME

Crawler Mount Side Plates...

Connection Vertical Force	391.93	kips
=	195.96	kips each plate
Effective Area	215.38	in.^2
fa	0.91	ksi
Top Bolt Line to CL Side Frame Conn.	29.42	inches
KL/r	50.95	
Cc	102.02	
Fa	26.19	ksi
fa/Fa	0.03	
Connection Lateral Force	373.74	kips
=	186.87	kips each plate
Moment	2,748.40	kip-inches
Effective Sy	71.79	in.^3
fb	38.28	ksi
Fb	49.40	ksi
Side Plate S.R.	**0.81 ≤ 1.00**	**O.K.**
Effective Area at Access Hole	191.38	in.^2
fa	1.02	ksi
Fa	26.19	ksi
fa/Fa	0.04	
Connection Lateral Force	186.87	kips each plate
Top Bolt Line to Top of Access Hole	16.92	inches
Moment at Top of Access Hole	412.52	kip-inches
Moment at Bottom of Access Hole	1,596.33	kip-inches
Effective Sy	63.79	in.^3
fb	25.02	ksi
Fb	49.40	ksi
Side Plate S.R.	**0.55 ≤ 1.00**	**O.K.**
Length of Top Stiffener Plate	16.87	inches
Angle of Top Stiffener Plate	11.98	degrees from horizontal
Force in Top Stiffener	802.73	kips
fa	8.73	ksi
KL/r	58.43	
Cc	107.00	
Fa	22.98	ksi
Stiffener Plate S.R.	**0.38 ≤ 1.00**	**O.K.**
Weld v	8.73	kips per inch
Weld V	11.14	kips per inch
Side Plate Weld S.R.	**0.78 ≤ 1.00**	**O.K.**

Crawler Mount Connections...

Maximum Vertical Reaction	195.96	kips per plate
Shear Block Weld v	4.90	kips per inch
Weld V	5.57	kips per inch
Weld S.R.	**0.88 ≤ 1.00**	**O.K.**
Bolted Connection Moment	2,748.40	kip-inches
Tension per Bolt	28.73	kips
Allowable Tension	34.60	kips
Bolt S.R.	**0.83 ≤ 1.00**	**O.K.**

CHASSIS SIDE FRAME

Jack Mounting Pad Stress Analysis...

Case 1 - No Horizontal Loads

Shear	54.71	kips
Moment	447.93	kip-inches

Case 2 - Maximum Horizontal Loads

Web Reaction 1	98.83	kips
Web Reaction 2	56.14	kips
Shear	98.83	kips
Moment	809.16	kip-inches
Maximum Shear	98.83	kips
fv	17.28	ksi
Fv	20.00	ksi
Shear S.R.	**0.86 ≤ 1.00**	**O.K.**
Maximum Moment	809.16	kip-inches
Area	52.38	in.^2
y bar (from bottom fiber)	14.60	inches
y bar (from top fiber)	2.65	inches
c	14.60	inches
Ix	451.97	in.^4
Sx	30.97	in.^3
fb	26.13	ksi
Fb	30.00	ksi
Bending S.R.	**0.87 ≤ 1.00**	**O.K.**

Local Stresses Under Jack Mounting Plates...

P	116.53	kips
N	0.50	inch
k	3.06	inches
J10-2 Ra	197.66	kips
J10-2 S.R.	**0.59 ≤ 1.00**	**O.K.**
J10-4 Ra	184.29	kips
J10-4 S.R.	**0.63 ≤ 1.00**	**O.K.**
Shear Strength of Diaphragm Plate	7.50	kips per inch
Weld v at Shear Strength	3.75	kips per inch
Weld V	4.64	kips per inch
Weld S.R.	**0.81 ≤ 1.00**	**O.K.**

Chassis Component Dead Weights...

	Weight, pounds	LCG, inches
Chassis Side Beam Dead Weight	22,900	121.881
Center Section Dead Weight	6,255	35.125
Chassis Machinery Dead Weight	7,320	44.871
Total Dead Weight of Chassis	59,375	103.247
LCG From CL Rear Bolt Group		7.802

CENTER SECTION

Dimensions and Loads...

Depth	36.000	inches
Outer Web Thickness	0.375	inch
Outer Web Spacing, out-to-out	68.250	inches
Web Cut-out Height	20.000	inches
Web Cut-out Width	71.750	inches
Web Stem Clear Depth at Flange	7.250	inches
Web Stem Clear Depth at End Plate	3.125	inches
Inner Web Thickness	0.625	inch
Inner Web Spacing, out-to-out	34.000	inches
Flange Thickness	0.750	inch
Flange Width	70.250	inches
Length of Center Section	82.000	inches
Fy	50	ksi (ASTM A572 Grade 50)
Weld Size	5/16	inch
Filler Strength	70	ksi
Connection Plate Thickness	2.000	inches
Fy	50	ksi (ASTM A572 Grade 50)
Flange Weld Size	3/4	inch (full penetration)
Number of Sides Welded	2	(fillet weld on opposite side)
Web Weld Size	7/16	inch
Number of Sides Welded	2	
Filler Strength	70	ksi
Outer Bolt Column Spacing	63.500	inches
Inner Bolt Column Spacing	56.000	inches
Bolt Column Spacing	3.750	inches
Bolt Pattern Height	30.250	inches
Vertical Bolt Spacing	3.500	inches
Number of Bolt Columns	4	
Number of Bolts per Column	9	(36 bolts total per connection)
Bolt Diameter	1.500	inches
Bolt Grade	SAE Grade 5	
Allowable Tension Load	77.70	kips
Allowable Shear Load	53.00	kips (threads excluded)
Side Frame Spacing, c-c	190.00	inches
Mx due to Side Frame Torsion	1,611.79	kip-inches
My due to Steering Force	46,202.54	kip-inches
Mz due to Diagonal Support Pattern	24,307.75	kip-inches

CENTER SECTION

Section Properties and Stress Analysis...

Ix	39,082.63	in.^4
Sx	2,171.26	in.^3
Iy	67,872.01	in.^4
Sy	1,932.30	in.^3
Sz	1,470.59	in.^3
fbx	0.74	ksi
fby	23.91	ksi
Fb	30.00	ksi
Bending S.R.	**0.82 ≤ 1.00**	**O.K.**
Center Web Shear	39.31	kips
fv due to Vertical Shear	0.87	ksi
fv due to Torsion	16.53	ksi
Fv	20.00	ksi
Web Shear S.R.	**0.87 ≤ 1.00**	**O.K.**

Bolted Connection Analysis...

Maximum Vertical Shear	39.31	kips
Shear per Bolt	1.09	kips (all bolts carry the load)
Maximum Horizontal Shear	243.17	kips due to crawler drawbar pull
Shear per Bolt	15.20	kips (4 bolts per column act)
Maximum Torsion	24,307.75	kip-inches
CL Bolt Group to CL Bolt Group (hor.)	59.75	inches
Maximum Shear per Bolt	22.60	kips
Combined Shear per Corner Bolt	37.84	kips
Shear S.R.	**0.71 ≤ 1.00**	**O.K.**
Bolt Tension due to Mx	13.32	kips (top and bottom bolts only)
Bolt Tension due to My	42.96	kips
Peak Corner Bolt Tension	56.28	kips
Allowable Tension	58.58	kips
Tension S.R.	**0.96 ≤ 1.00**	**O.K.**
Equiv. Uniform Load of Side Bolts	21.48	kips per inch
End Plate Moment due to Bolt Tension	3,479.69	kip-inches
Effective Width of End Plate	35.13	inches
Outer Web Stem Height	3.13	inches
Inner Web Effective Stem Height	39.00	inches
Area	95.80	in.^2
y bar	6.25	inches
Iy	10,727.34	in.^4
Sy	308.68	in.^3
fb	11.27	ksi
Fb	30.00	ksi
End Plate S.R.	**0.38 ≤ 1.00**	**O.K.**
Flange Weld v due to Tension	18.49	kips per inch
Flange Weld v due to Shear	14.13	kips per inch
Flange Weld v	23.27	kips per inch
Weld V	33.64	kips per inch
Flange Weld S.R.	**0.69 ≤ 1.00**	**O.K.**
Web Weld v	10.88	kips per inch
Weld V	12.99	kips per inch
Web Weld S.R.	**0.84 ≤ 1.00**	**O.K.**

CASK HOLD-BACK STRAP

Nylon Strap Specifications...

Manufacturer	Lamco	
Product Number	EE-495	
Width	5.000	inches
Rated Tensile Capacity	27,500	pounds at S.F. = 5.0
Angle of Sling off Centerline	5.00	degrees

Tension Cylinder Specifications...

Cylinder Manufacturer	Prince Manufacturing Co.	
Model	PMC-44020	
Bore Diameter	4.000	inches
Rod Diameter	1.750	inches
Operating Pressure	2,800	psi
End Fitting Lug Thickness	0.500	inch
Clear Between End Lugs	1.125	inches
Pin Diameter	1.015	inches
Pin Fy	100	ksi (ASTM A311)

Strap Fitting Dimensions...

Pin Diameter for Strap	1.625	inches
Pin Fy	100	ksi (ASTM A311)
Clear Opening for Strap	5.500	inches
Fitting Thickness	0.500	inch
Hole Diameter	1.688	inches
Hole End Distance	1.750	inches
Hole Edge Distance	1.750	inches
Fitting Fy	50	ksi (ASTM A572 Grade 50)

Cylinder Mount Dimensions...

Fitting Thickness	1.000	inch
Hole Diameter	1.063	inches
Hole End Distance	1.250	inches
Hole Edge Distance	1.500	inches
Fitting Fy	50	ksi (ASTM A572 Grade 50)

Loads and Geometry...

Cask Weight	360,000	pounds
Hold-Back System Design Load	36,000	pounds
Maximum Strap Tension	18,069	pounds

Cylinder Check...

Tension	18,069	pounds
Cylinder Retract Capacity	28,451	pounds
Cylinder Load Ratio	**0.64 ≤ 0.80**	**O.K.**

CASK HOLD-BACK STRAP

Strap Check...

Tension	18,069 pounds
Allowable Tension	27,500 pounds
Strap Load Ratio	**0.66 ≤ 1.00 O.K.**

Strap Pin Stress Analysis...

Shear	9.03 kips
fv	4.36 ksi
Fv	40.00 ksi
Shear S.R.	**0.11 ≤ 1.00 O.K.**
Moment	15.81 kip-inches
fb	37.53 ksi
Fb	60.00 ksi
Bending S.R.	**0.63 ≤ 1.00 O.K.**
fp	11.12 ksi
Fp	45.00 ksi
Bearing S.R.	**0.25 ≤ 1.00 O.K.**

Strap Fitting Stress Analysis...

Clear Beyond Hole	0.906 inch
Clear to Side of Hole	0.906 inch
Effective Width to Side of Hole	0.680 inch
Allowable Stress at Pin Hole	22.50 ksi = 0.45 Fy per AISC
Hole Capacity	15.29 kips
Pin Hole S.R.	**0.59 ≤ 1.00 O.K.**

Cylinder Pin Stress Analysis...

Shear	9.03 kips
fv	11.17 ksi
Fv	40.00 ksi
Shear S.R.	**0.28 ≤ 1.00 O.K.**
Moment	4.33 kip-inches
fb	42.17 ksi
Fb	60.00 ksi
Bending S.R.	**0.70 ≤ 1.00 O.K.**
fp	17.80 ksi
Fp	45.00 ksi
Bearing S.R.	**0.40 ≤ 1.00 O.K.**

Cylinder Mount Stress Analysis...

Clear Beyond Hole	0.719 inch
Clear to Side of Hole	0.969 inch
Effective Width to Side of Hole	0.539 inch
Allowable Stress at Pin Hole	22.50 ksi = 0.45 Fy per AISC
Hole Capacity	24.26 kips
Pin Hole S.R.	**0.74 ≤ 1.00 O.K.**

CASK BUMPERS

Loads and Dimensions...

Maximum Longitudinal Force	36,000	pounds
Outer Tube Size	TS10x10x1/2	
Depth	10.000	inches
Wall Thickness	0.500	inch
Area	18.400	in.^2
Fy	46	ksi (ASTM A500 Grade B)
Inner Tube Size	TS8x8x1/2	
Depth	8.000	inches
Wall Thickness	0.500	inch
Area	14.400	in.^2
Fy	46	ksi (ASTM A500 Grade B)
Length, Base Pins to Joint Pin	10.000	inches
Length, Joint Pin to Cask Bearing	27.875	inches
Tube Gross Overlap	7.500	inches
Angle, Side Frame CL to Bumper CL	45.000	degrees
Joint Pin Diameter	1.500	inches
Fy	100	ksi (ASTM A311 Class B)
Base Pin Diameter	1.625	inches
Fy	100	ksi (ASTM A311 Class B)

Bumper Analysis...

Bumper Axial Load	25.46	kips
Maximum fa	1.77	ksi O.K.
Joint Pin Load	25.46	kips
Pin Shear	12.73	kips
fv	7.20	ksi
Fv	40.00	ksi
Shear S.R.	**0.18 ≤ 1.00**	**O.K.**
Moment	12.73	kip-inches
fb	38.41	ksi
Fb	89.82	ksi
Bending S.R.	**0.43 ≤ 1.00**	**O.K.**
Outer Tube fp	16.97	ksi
Outer Tube Fp	41.40	ksi
Inner Tube fp	16.97	ksi
Inner Tube Fp	41.40	ksi
Bearing S.R.	**0.41 ≤ 1.00**	**O.K.**
Base Pin Load	12.73	kips each
Pin Shear	6.36	kips
fv	3.07	ksi
Fv	40.00	ksi
Shear S.R.	**0.08 ≤ 1.00**	**O.K.**
Moment	18.30	kip-inches
fb	43.43	ksi
Fb	89.82	ksi
Bending S.R.	**0.48 ≤ 1.00**	**O.K.**
Outer Tube fp	7.83	ksi
Outer Tube Fp	41.40	ksi
Side Frame fp	5.22	ksi
Side Frame Fp	45.00	ksi
Bearing S.R.	**0.12 ≤ 1.00**	**O.K.**

SIDE TOW EYE DESIGN

Lug Plate Dimensions...

Pin Diameter	3.500	inches
Hole Diameter	6.000	inches
End Radius	6.000	inches
Side Radius	6.000	inches
Thickness	1.500	inches
CL Hole to Base	6.000	inches
Plate Width at Base	12.000	inches
Angle of Load off CL of Plate	5.000	degrees in the plane of the plate
Plate Fy	50	ksi (ASTM A572 Grade 50)
Pin Fy	50	ksi
Lug Plate Weld Size	3/8	inch
Filler Strength	70	ksi
End Plate Thickness	0.750	inch
End Plate Weld Size	5/16	inch
Filler Strength	70	ksi

10% Unpowered Rolling Resistance	51,146	pounds
Grade Resistance on 10.00% Grade	51,146	pounds
Skewing Force on One Crawler	66,357	pounds
Design Total Braking Force	0	pounds (r.r. overcomes grade force)
Design Drawbar Pull Force	117,504	pounds per lug in a turn
Design Load per Lug	117.504	kips

Lug Plate AISC Allowable Load...

Plate Effective be	2.250	inches
Plate a	3.000	inches
Bearing Area	5.250	in.^2
Fp	45.00	ksi
Dp / Dh	0.58	
Cr	0.78	
Allowable Tensile Stress	22.50	ksi per AISC
Allowable Load at Pin Hole	117.95	kips
Pin Hole S.R.	**1.00 ≤ 1.00**	**O.K.**

Check Body for Combined Axial and Bending Loads...

Body Area	18.00	in.^2
ft	6.50	ksi
Ft	30.00	ksi
Body Section Modulus	36.00	in.^3
fb	1.71	ksi
Fb	30.00	ksi
Body S.R.	**0.27 ≤ 1.00**	**O.K.**

Check Weld Stresses...

Length of Weld All Around	48.00	inches (includes gussets)
Sx of Weld All Around	192.00	in.^2 (includes gussets)
Lug Plate Weld v	2.76	kips per inch
Weld V	5.57	kips per inch
Lug Plate Weld S.R.	**0.50 ≤ 1.00**	**O.K.**
Effective Length of End Plate Weld	37.50	inches
Effective Sx of End Plate Weld	587.25	in.^2
End Plate Weld v	3.23	kips per inch
Weld V	4.64	kips per inch
End Plate Weld S.R.	**0.70 ≤ 1.00**	**O.K.**

CENTER TOW EYE DESIGN

Lug Plate Dimensions...

Pin Diameter	3.000	inches
Hole Diameter	4.250	inches
End Radius	5.500	inches
Side Radius	7.250	inches
Thickness	2.250	inches
CL Hole to Base	6.500	inches
Plate Width at Base	24.000	inches
Overlap to Center Section Bottom Flange	6.000	inches
Angle of Load off CL of Plate	30.000	degrees in the plane of the plate
Plate Fy	50	ksi (ASTM A572 Grade 50)
Lug Plate Weld Size	1/2	inch
Filler Strength	70	ksi

10% Unpowered Rolling Resistance	51,146	pounds
Grade Resistance on 10.00% Grade	51,146	pounds
Skewing Force on One Crawler	66,357	pounds
Design Total Braking Force	0	pounds (r.r. overcomes grade force)
Design Drawbar Pull Force	168,650	pounds
Design Load per Lug	168.650	kips

Lug Plate AISC Allowable Load...

Plate Effective be	2.531	inches
Plate a	3.375	inches
Bearing Area	6.750	in.^2
Fp	45.00	ksi
Dp / Dh	0.71	
Cr	0.81	
Allowable Tensile Stress	22.50	ksi per AISC
Allowable Load at Pin Hole	206.37	kips
Pin Hole S.R.	**0.82 ≤ 1.00**	**O.K.**

Check Body for Combined Axial and Bending Loads...

Body Area	54.00	in.^2
ft	2.70	ksi
Ft	30.00	ksi
Body Section Modulus	216.00	in.^3
fb	2.54	ksi
Fb	30.00	ksi
Body S.R.	**0.17 ≤ 1.00**	**O.K.**

Check Weld Stresses...

Weld Analysis Using AISC Table 8-6, page 8-82:

P	168.65	kips
L	24.00	inches
KL	6.00	inches
AL	9.50	inches
K	0.25	
A	0.40	
Coefficient C	4.55	
D min	3.09	
D provided	8.00	
Lug Plate Weld S.R.	**0.39 ≤ 1.00**	**O.K.**
Lower Flange fv	3.82	ksi
Fv	20.00	ksi
Shear S.R.	**0.19 ≤ 1.00**	**O.K.**

STABILITY EVALUATION

Input Dimensions...

Gross Vehicle Weight	511,464	pounds
Crawler Track Spacing, c-c	190.00	inches
Road Superelevation for Stability	4.00%	
=	2.29	degrees
Maximum Height of Transporter	291.44	inches
VCG at Travel Height	104.10	inches (est.)
Height of Center of Cask Area	117.25	inches (est.)
Height of Center of Transporter Area	72.86	inches (est.)

Stability Analysis...

Wind Force on Cask at 35 mph	433	pounds
Wind Force on Transporter at 35 mph	829	pounds
Wind Force on Cask at 115 mph	4,677	pounds
Wind Force on Transporter at 115 mph	8,951	pounds
Overturning Moment	100,043	pound-feet
Stabilizing Moment	3,549,386	pound-feet
Stability Safety Factor	**35.48 ≥ 1.10**	**O.K.**

COMPONENT WEIGHT TAKE-OFF CALCULATIONS

Lift Link Weight Take-Off

Item	Quantity	Wt. each	LCG, in.	Weight, lbs.
Top Bars	3	96		288
U Plates	2	304		608
Assembly Pins	2	34		68
Bearing Plate	1	11		11
Slider Pad	1	9		9
Misc. parts	1	15		15
		Computed Weight		999
		Design Weight to be Used		1,000

Side Shifter Cylinder Weight Take-Off

Item	Quantity	Wt. each	LCG, in.	Weight, lbs.
Side Shift Cylinder - PMC-42012	1	22		22
		Computed Weight		22
		Design Weight to be Used		22

Header Beam Weight Take-Off

Item	Quantity	Wt. each	LCG, in.	Weight, lbs.
Fab. Box x 14.29' long	1	4,743		4,743
Pivot Plates	4	20		80
Misc. parts	1	350		350
		Computed Weight		5,173
		Design Weight to be Used		7,425

Boom Base Section Weight Take-Off

Item	Quantity	Wt. each	LCG, in.	Weight, lbs.
Flange Plates	2	212		424
Web Plates	2	252		504
Cylinder Support Plates	2	100		200
Collar Gusset Plates	4	31		124
Collar Side Plates	2	37		74
Collar Vertical Plates	4	15		60
Locking Pins	2	36		72
Slider Pads	8	1		8
		Computed Weight		1,466
		Design Weight to be Used		1,470

Boom Power Section Weight Take-Off

Item	Quantity	Wt. each	LCG, in.	Weight, lbs.
Flange Plates	2	216		432
Web Plates	2	200		400
Top Plate	1	125		125
Pivot Plates	2	20		40
Cylinder Support Plates	2	86		172
Doubler Plates	2	14		28
Pivot Pin	1	38		38
Slider Pads	8	1		8
		Computed Weight		1,243
		Design Weight to be Used		1,250

Boom Telescope Cylinder Weight Take-Off

Item	Quantity	Wt. each	LCG, in.	Weight, lbs.
63" Stroke Cylinder	1	552		552
Pins	2	20		40
		Computed Weight		592
		Design Weight to be Used		600

Base Frame Weight Take-Off

Item	Quantity	Wt. each	LCG, in.	Weight, lbs.
Side Plates	2	492		984
End Plate	1	134		134
End Plate	1	134		134
End Plate Access Hole Covers	2	34		68
Bottom Plates	2	81		162
Bolt Plates	2	45		90
Bolt Area Back Plates	2	7		14
Hydraulic Couplings	2	0.1		0.2
		Computed Weight		1,586
		Design Weight to be Used		1,590

Chassis Side Beam Weight Take-Off

Item	Quantity	Wt. each	LCG, in.	Weight, lbs.
Flanges	2	2,735	115.126	5,470
Webs	2	416	135.000	832
Lower Side Plate	1	5,640	140.000	5,640
Lower Side Plate	1	5,640	140.000	5,640
Lower Bottom Plate	1	566	43.606	566
Lower Front Plate	1	21	1.188	21
Lower Rear Plate	1	27	82.000	27
Chassis End Plates	2	55	135.000	110
Upper Front Access Plate	1	19	1.188	19
Upper Rear Access Plate	1	28	82.000	28
Bolt Plate	1	1,398	35.125	1,398
Lower Bolt Plate Stiffeners	2	113	35.125	226
Upper Bolt Plate Stiffeners	2	86	35.125	172
Internal Diaphragms	2	55	146.500	110
Crawler Shear Blocks	6	34	141.125	204
Lower Side Plate Stiffeners	4	391	141.125	1,564
Jack Mounting Pads	2	205	146.500	410
Rear Tow Eyes	2	45	-5.000	90
Front Tow Eye	1	45	275.000	45
Adjustable Bumper Assembly	1	319	75.000	319
	Computed Weight and LCG from Rear of Vehicle		121.881	22,891
		Design Weight to be Used		22,900

Center Section Weight Take-Off

Item	Quantity	Wt. each	LCG, in.	Weight, lbs.
Flanges	2	1,061		2,122
Side Webs	2	121		242
Center Webs	2	434		868
Bolt Plates	2	1,398		2,796
Handling Lugs	4	2		8
Conection Bolts, Nuts & Washers	72	3.3		216
		Computed Weight		6,252
		Design Weight to be Used		6,255

Crawler Assemblies Weight Take-Off

Item	Quantity	Wt. each	LCG, in.	Weight, lbs.
Intertractor Crawler Assemblies	2	36,400	141.882	72,800
	Computed Weight and LCG from Rear of Vehicle		141.882	72,800
		Design Weight to be Used		72,800

Misc. Mechanical Equipment Weight Take-Off

Item	Quantity	Wt. each	LCG, in.	Weight, lbs.
Engine	1	2,400	36.000	2,400
Hydraulic Pumps	2	340	36.000	680
Oil Tank with Oil	1	2,100	40.000	2,100
Restraint Strap	1	26	149.000	26
Strap Pins	2	4	80.000	8
Strap Fittings	2	15	80.000	30
Strap Fitting Mount	1	9	80.000	9
Tension Cylinder - PMC-44020	1	58	90.000	58
Strap Cylinder Mount	1	9	80.000	9
Misc. equipment, oper. cab, etc.	1	2,000	60.000	2,000
Computed Weight and LCG from Rear of Vehicle			44.871	7,320
Design Weight to be Used				7,320

Summary of Transporter Weights

Item	Quantity	Wt. each	LCG, in.	Weight, lbs.
Lift Links	2	1,000	146.500	2,000
Side Shifter Cylinders	2	22	146.500	44
Header Beam	1	7,425	146.500	7,425
Boom Base Sections	2	1,470	146.500	2,940
Boom Power Sections	2	1,250	146.500	2,500
Boom Telescope Cylinders	2	600	146.500	1,200
Base Frames	2	1,590	146.500	3,180
Chassis Side Beams	2	22,900	121.881	45,800
Chassis Center Section	1	6,255	35.125	6,255
Crawler Assemblies (pair)	1	72,800	141.882	72,800
Misc. Mechanical Equipment	1	7,320	44.871	7,320
Computed Weight and LCG from Rear of Vehicle			127.325	151,464
LCG from CL of Crawler Track Bearing Length			14.557 inches aft	

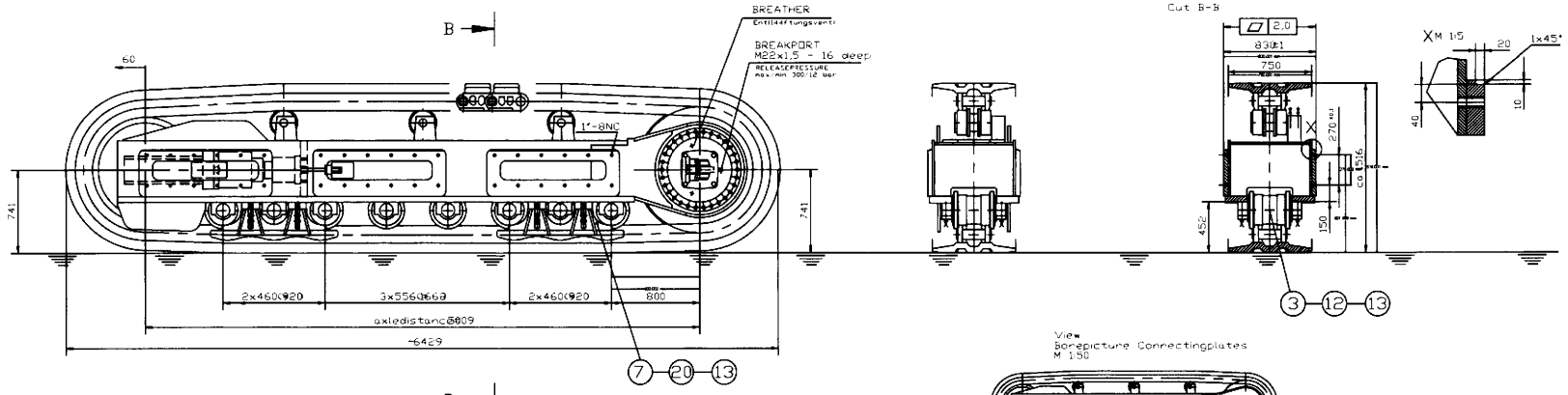
Loaded Transporter Weight and LCG

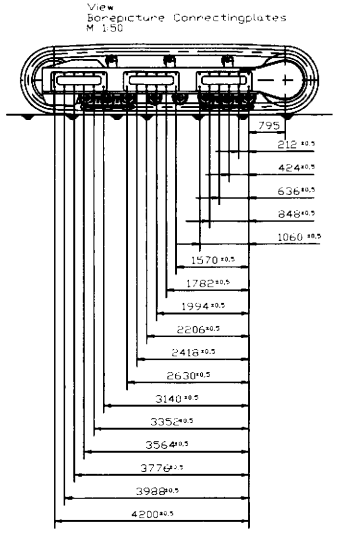
Item	Quantity	Wt. each	LCG, in.	Weight, lbs.
Transporter	1	151,464	127.325	151,464
Cask	1	360,000	146.500	360,000
Computed Weight and LCG from Rear of Vehicle			140.822	511,464
LCG from CL of Crawler Track Bearing Length			1.060 inches aft	

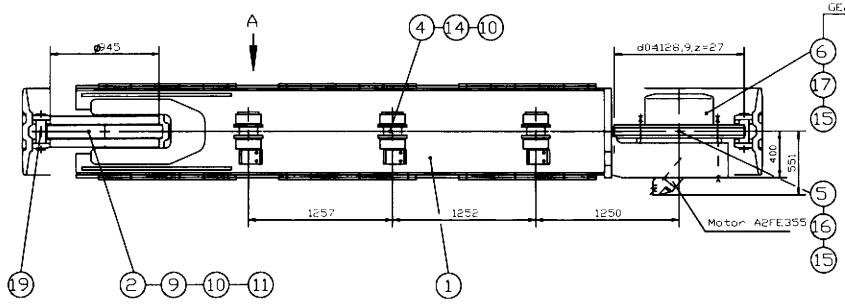
Summary of Crawler Loads

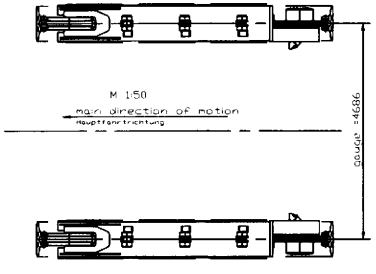
	Load, pounds	Average Pressures, psf	psi	GVW, pounds
Empty Transporter	75,732	1,873	13	151,464
With Cask Centered	255,732	6,324	44	511,464

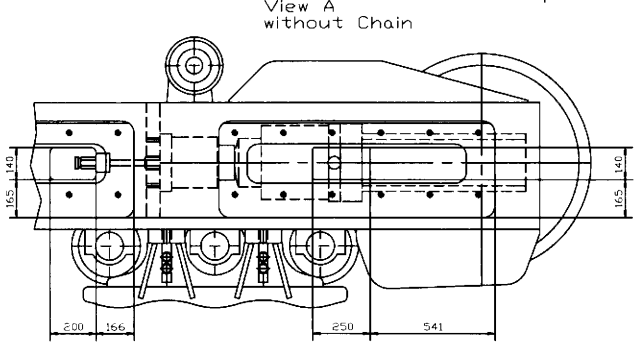
SECTION 2.0 - VENDOR DATA











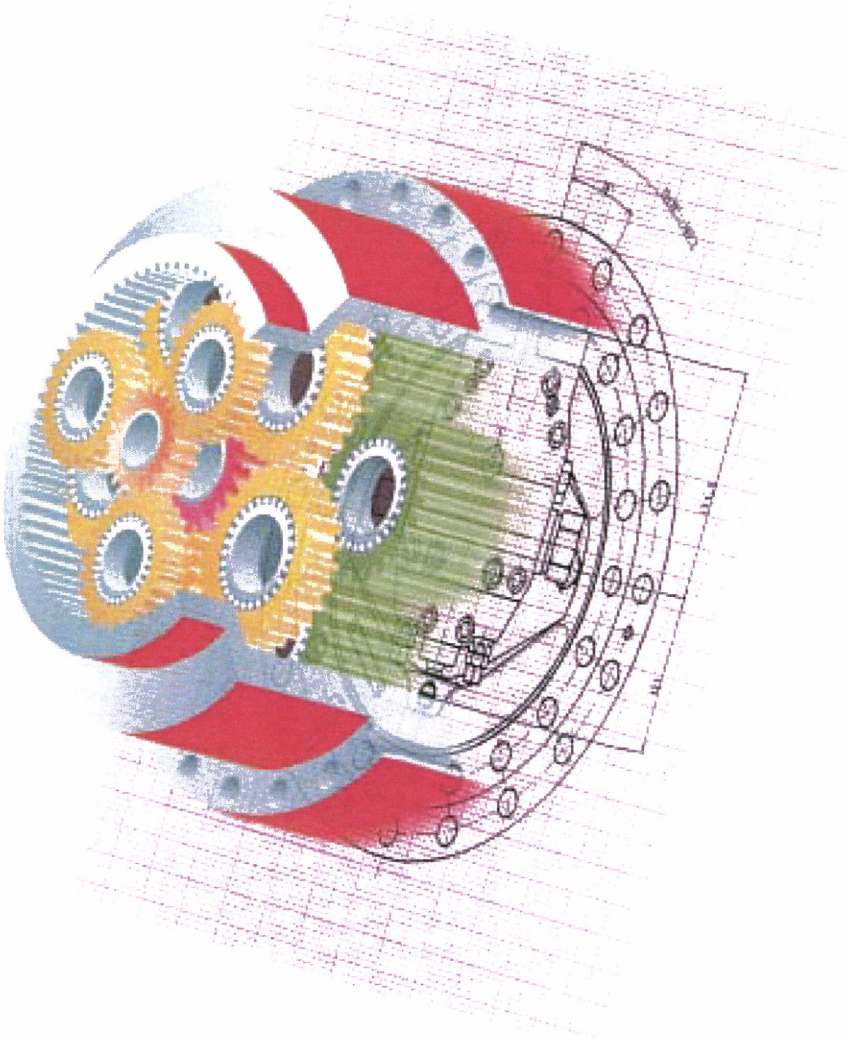
Confirmation for Drawing:
UQ909D00N00017/18

SIDEFRAME RIGHT AS DRAWN CAT-NO: UQ909D00N00018
Raupenfahrschiff rpl. rechts wie gezeichnet Kat-Nr.

SIDEFRAME LEFT IS MIRRORIMAGE CAT-NO: UQ909D00N00017
Raupenfahrschiff rpl. links spiegelbildlich Kat-Nr.

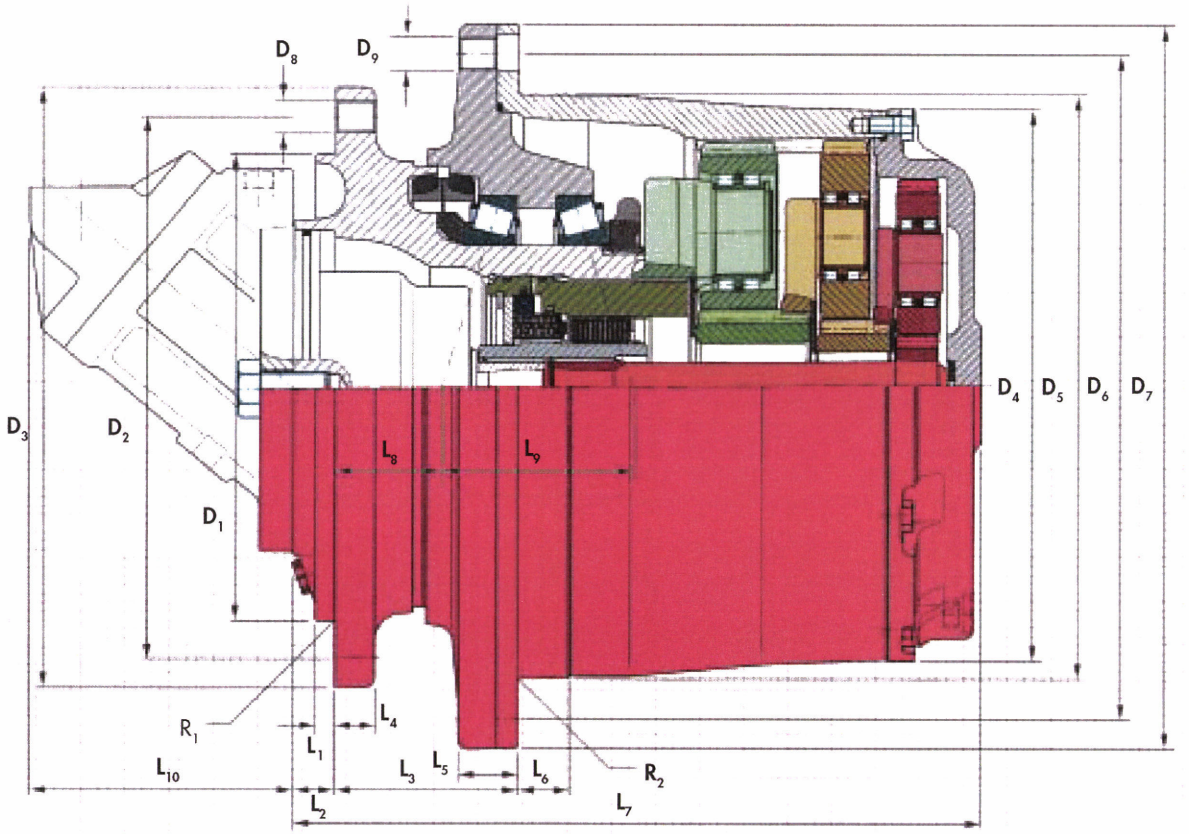
A=5009, G= 4686, 52-link-chain
52-Glieder-Kette

MA145E DIN TOLERANZANGABEN NACH KN 930					WERKSTOFF MATERIAL	GEWICHT WEIGHT	CODE wwc011102_0
	INDEX	DATUM	NAME	NORM	-	~16.5 t	TYPE 89
	GEZ.	06.11.02	Bec	MAßSTAB SCALE 1:20	Sideframe RH/LH Fahrschiff re/li.		
	GEPR.						
Linde Material Handling					ZEICHNUNGS NR/PART NO		NORM-INDEX
					WWC011102		1 /
PASSMAßE/FITS					ERSATZ FÜR / ERSATZ DURCH		



O&K Antriebstechnik

Final Drive



Standard execution
- compact structure
- high performance
- 3-7 planetary wheels per stage
- notchless ground tooth root
- different ratios
- integrated disc-brake
- suitable for various hydraulic motors
- high availability by highest teeth- and production quality

Proven applications
- track drives
- chain drives
- reel- and winchdrives

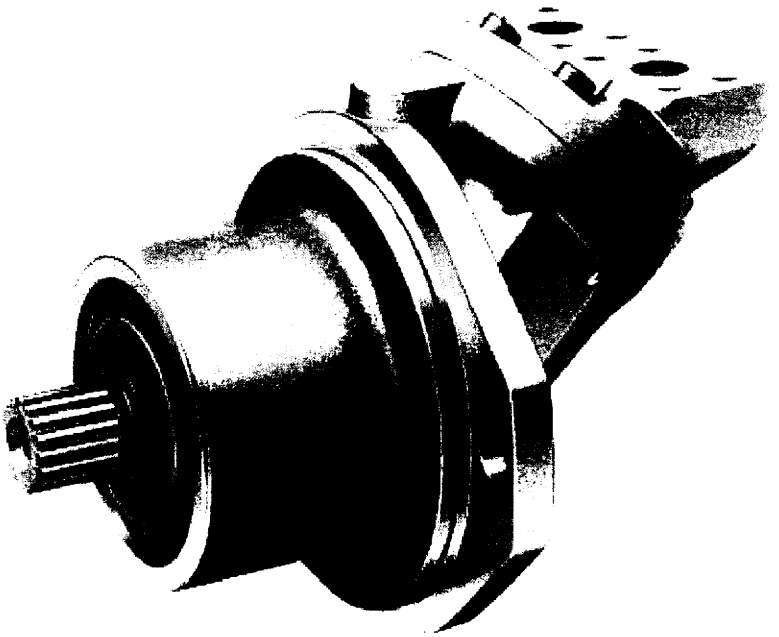
Special executions on request
- mechanical disconnect device

Type		FD 10	F 13	FD 20	F 30	F40		F 44	F 55	F 60	F 80	F 100	F 130	F 180	F 220	F 360	F 620	F 800	F 1100	F 2200
Output torque 1)	kNm	10	13	20	30	40		44	55	60	80	100	130	180	220	360	615	800	1100	2200
Ratio 2)	i	35	19	81	81	66		94	94	108	90	84	85	**206**	190	**223**	**322**	**283**	**406**	**552**
		51	**93**	90	90	81		124	**124**	124	102	121	167		**248**					
		65	108	**101**	**101**	90		137	137	**147**	120	142	**206**		290					
			122	137	137	101		**148**	148	168	**147**	**175**								
			140	171	171	117		185	185	185		192								
			178	228	228	**124**						226								
			229			142														
						181														
Capacity of bearing																				
C-dynamic	kN	194	194	194/194	132/194	224		224	224	300	300	498	523	787	765	1 040	1960	2485	3900	5100
Co-static	kN	325	325	325/315	255/325	405		405	405	570	570	1010	980	1650	1660	2450	4150	5941	7650	11600
Weight3)	kg	47	49	72	94	120		165	177	230	215	325	452	700	797	1080	2905	3764	7220	10736
Multi-disc brake																				
Locking torque	Nm	200	200	300	300	420		420	420	450	600	600	750	1375	1200	1700	1300	1000	1750	2300
Release pres. min.	bar	16	18	16	16	18		15	15	15	18	17	17	19.5	15	12	25	7.8	20	22
Hydraulic motor																				
Hydromatik 4)																				
fixed:	A 2 FE	28	28	28	45	45	(80)	45	80	80	80	107	107	160	160	355	(2x) 250	(2x) 250	(2x) 250	(2x) 355
		32	32	32	56	56	(90)	56	90	90	90	125	125	180	180					
											107	160	160							
					63	63		63			125	180	180							
variable:																				
	A6VE/VM	28	28	28	55	55	80	55	80	80	80	107	107	160	160	355	(2x) 250	(2x) 250	(2x) 250	(2x) 355
	A10VE	45	45	45							107	160	160							
											160									
Dimensions																				
L 1	mm	10	10	10	13	16	12	20	12	20	20	35	45	30	18	100	57.5	25	60	70
L 2	mm	40	40	41	25	16	35	30	25	25	37	35	45	30	52	100	95	413	395.5	591
L 3	mm	72	72	75	75	91	91	91	110	130	90	165	190	168	166.5	130	245	229	503	343
L 4	mm	13.5	13.5	15	15	21	21	24	24	28	22	28	35	40	40	40	52.5	46	74	80
L 5	mm	26	26	28	29	34	34	36	36	43	35	53	58	56	61	60	50	58	300	100
L 6	mm	30	30	25	25	26	26	30	30	30	24	43	45	21.5	35	80	75	170	-	80
L 7	mm	243	266	300	323	338	357	399	413	409	415	461	530	534.5	580.5	658	1181.5	1315	1483	1846
L 8	mm	15.3	15.3	15.3	28.5	38	38	45	64	28	34	32	50.5	50.3	16	-25	50	161/163	176	217
L 9	mm	88.4	88.4	86.3	89	100	100	113	113	127	123	139	147	141.4	187.5	215	233	257/253	368	376
Hydromatik 4)																				
L 10 fixed	mm		-		146	146	157	146	157	157	157	178	178	211	211	231		-	-	-
L 10 variable	mm		-		197	197	202	197	202	202	202	205	205		312	-		-	-	432
R 1	mm	1.6	1.6	2.5	2.5	2.5	2.5	4	1	8	4	12/60	25	4	35°/16/16	18°/100/16	4	6	10	10
R 2	mm	1.6	1.6	2.5	2.5	2.5	2.5	2.5	2.5	6	2.5	5	4	3	4	10	-	8	6	10
D 1	mm	190	190	240	240	240	270	240	280	350	330	390	390	450	460	580	730	830	1110	1288
D 2	mm	230	230	275	275	285	310	285	325	400	370	460	500	510	600	680	810	980	1230	1400
D 3	mm	256	256	304	304	320	345	320	360	445	410	500	550	560	650	735	880	1050	1310	1500
D 4	mm	215	215	250	269	294	294	331	331	357	364	407	449	528	540	649	880	916	1116	1224
D 5	mm	220	220	270	270	295	295	350	350	375	400	408	450	535	542	650	885	920	-	1230
D 6	mm	260	260	305	305	335	335	400	400	425	450	460	500	600	600	720	965	976	1170	1320
D 7	mm	290	290	335	335	370	370	435	435	466	490	500	550	650	650	775	1020	1055	1226	1400
D 8 / D 9	M	16/16	16/16	16/16	16/16	20x1.5	20x1.5	20x1.5	20x1.5	24x2	24x2	24x2	24x2	24x2/27x2	24 x 2	30	30x2	30x2	36/30	42x3
						16x1.5	16x1.5													
Qty. D 8 / D 9		12/8	12/8	18/18	18/18	20/20	16/20	20/20	24/20	24/24	20/20	30/24	32/32	30/30	38/38	30/30	41/48	48/48	52/52	50/48

[1] Stated torques are peak values for short duration
[2] Other ratios on application
[3] Without Hydraulic motor
[4] Other Hydraulic motors on request

Project related installation drawings can be made availble on request as dimensions and technical data are subject to change due to continues development.

MANNESMANN REXROTH	Fixed Displacement Plug-In Motor A2FE Series 6, axial tapered piston, bent axis design for mounting in mechanical gearboxes		RE 91008/03.97
Brueninghaus Hydromatik	Sizes 28...355	Nom. Pressure up to 400 bar Peak Pressure up to 450 bar	replaces 04.96



The fixed displacement plug-in motor A2FE is equipped with a standard axial tapered piston rotary group of bent axis design.

Hydrostatic plug-in motors are intended primarily for installation in mechanical gearboxes, e.g. track drive gear boxes.

The design of the motor with the mounting flange in the centre of the housing allows it to be almost fully integrated into a mechanical gearbox to give an extremely compact unit.

– complete unit, ready assembled and tested

– easy assembly,
simply «plugs-in» to mechanical gearboxes

– no instalation tolerances to consider

Fixed Displacement Plug-In Motor A2FE

Ordering Code / Standard Program

	A2F		E		/	6		W	-				

Hydraulic Fluid

Mineral oil (no code)		
HF-fluids	sizes 28...180 (no code)	
	size 250...355 [1])	E-

Axial piston unit

Bent axis design, fixed displacement	A2F

Drive shaft bearings

	28...180	250...355	
mechanical bearings (no code)	●	●	
Long-Life bearings	–	●	L

Mode of operation

Plug-in motor	E

Size

≙ Displacement V_g (cm³)	28	32	45	56	63	80	90	107	125	160	180	250	355

Sizes 28...180: production plant Elchingen; Sizes 250...355: production plant Horb

Series

	6

Index

	sizes 28...180	1
	size 250...355	0

Direction of rotation

viewed on shaft end	alternating	W

Seals

	28...180	250...355	
NBR (nitril-caoutchouc), shaft seal in FPM	●	–	N
FPM (fluor-caoutchouc)	●	●	V

Shaft end

	28	32	45	56	63	80	90	107	125	160	180	250	355	
Splined shaft end	●	●	●	●	●	●	●	●	●	●	●	–	–	A
	●	–	●	●	●	●	●	●	●	●	●	●	●	Z

Mounting flange

	28...180	250...355	
Special 2-hole flange	●	–	L
Special 4-hole flange	–	●	M

Service line connections

			28	32	45	56	63	80	90	107	125	160	180	250	355	
Ports A and B SAE, rear end	01	0	●	●	●	●	●	●	●	●	●	●	●	●	–	010
Ports A and B SAE at side, same side (metr. mounting threads)	10	0	●	●	●	●	●	●	●	●	●	●	●	–	●	100
		6	●	●	●	●	●	●	●	–	–	–	–	–	–	106
port plate with integrated pressure relief valves, for mounting a motion control valve	17	1	–	–	–	–	–	–	–	●	●	–	–	–	–	171
port plate with integrated pressure relief valves, for mounting a motion control valve	18	1	●	●	●	●	●	●	●	●	●	●	●	-	-	181
port plate with integrated pressure relief valves	19	1	●	●	●	●	●	●	●	●	●	●	●	-	-	191
		2	●	●	●	●	●	●	●	●	●	●	●	-	-	192

Valves

without valves (no code)	0
with pressure relief valves (*without* pressure sequence range)	1
with pressure relief valves (*with* pressure sequence range)	2
with integrated flushing valve	6

[1]) only in connection with drive shaft bearings "L"

● = available
– = not available

□ = preferred program
(preferred types see page 5)

Technical Data

Fluid

We request that before starting a project detailed information about the choice of pressure fluids and application conditions are taken from out catalogue sheets RE 90220 (mineral oil), RE 90221 (environmentally acceptable hydraulic fluids) and RE 90223 (fire resistance fluids, HF).
When using HF- or environmentally acceptable hydraulic fluids possible limitations for the technical data have to be taken into consideration. If necessary please consult our technical department (please indicate type of the hydraulic fluid used for your application on the order sheet).

Operating viscosity range

In order to optain optimum efficiency and service life, we recommend that the operating viscosity (at operating temperature) be selected from within the range:

ν_{opt} = operating viscosity 16...36 mm²/s

referred to the loop temperature (closed circuit) or tank temperature (open circuit).

Viscosity limits

The limiting values for viscosity are as follows:

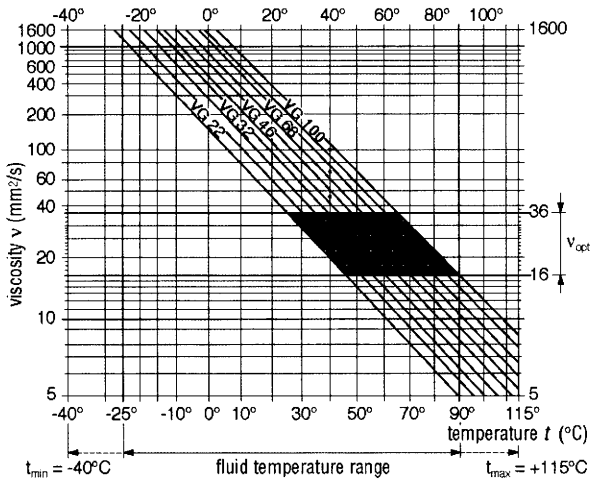
sizes 28...180
ν_{min} = 5 mm²/s,
short term at a max. permissible temperature of t_{max} = 115°C
ν_{max} = 1600 mm²/s, short term on cold start (t_{min} = -40°C)

sizes 250...355
ν_{min} = 10 mm²/s
short term at a max. permissible leakage oil temp. of t_{max} = 90°C
ν_{max} = 1000 mm²/s,
short term on cold start (t_{min} = -25°C)

Please note that the max. fluid temperature is also not exceeded in certain areas (for instance bearing area).

At temperatures of -25°C up to -40°C special measures may be required for certain installation positions. Please contact us for further information.

Selection diagram



Notes on the selection of the hydraulic fluid

In order to select the correct fluid, it is necessary to know the operating temperature in the loop (closed circuit) or the tank temperature (open circuit) in relation to the ambient temperature.
The hydraulic fluid should be selected so that within the operating temperature range, the operating viscosity lies within the optimum range (ν_{opt}) (see shaded section of the selection diagram). We recommend that the highest possible viscosity range should be chosen in each case.
Example: At an ambient temperature of X°C the operating temperature (closed circuit: loop temperature; open circuit: tank temperature) is 60°C. Within the operating viscosity range (ν_{opt}; shaded area), this corresponds to viscosity ranges VG 46 or VG 68. VG 68 should be selected.
Important: The leakage oil (case drain oil) temperature is influenced by pressure and motor speed and is always higher than the circuit or tank temperature. However, at no point in the circuit may the temperature exceed 115°C for sizes 28...180 or 90°C for size 250...355.
If it is not possible to comply with the above conditions because of extreme operating parameters or high ambient temperatures please consult us.

Filtration

The finer the filtration the better the achieved purity grade of the pressure fluid and the longer the life of the axial piston unit.
To ensure the functioning of the axial piston unit a minimum purity grade of:

9 to NAS 1638
6 to SAE
18/15 to ISO/DIS 4406 is necessary.

At very high temperatures of the hydraulic fluid (90°C to max. 115°C, not permissible for sizes 250...355!) at least cleanless class 8 to NAS 1638
5 to SAE
17/14 to ISO/DIS 4406 is necessary.

If above mentioned grades cannot be maintained please consult supplier.

Direction of Flow

Clockwise rotation	Anti-clockwise rotation
A to **B**	**B** to **A**

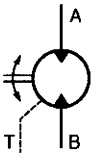
Speed range

There is no limitation on minimum speed n_{min}. If uniformity of rotation is required, however, speed n_{min} should not be allowed to fall below 50 rpm.
See table on page 5 for max. permissible speeds.

Installation position

Any installation position possible. In case of vertical installation (drive shaft up) please contact us. The motor housing must be filled with fluid prior the commissioning, and must remain full whenever it is operating.
For extensive information on installation postition, please consult our data sheet RE 90270 before completing your design work.

Symbol



Connections

A, B service line ports
T case drain port

Technical Data

Operating pressure range
Maximum pressure at port A or B
(Pressure data to DIN 24312)

Sizes 28...180	Shaft end A	Shaft end Z *)	
	sizes 28...180	sizes 28,45,56 80,107,160	sizes 63,90 125,180
Nominal pressure p_N	400 bar	400 bar	350 bar
Peak pressure p_{max}	450 bar	450 bar	400 bar

*) Attention: shaft end Z with drives of radial force loads at the drive shaft (pinion V-belt drives) necessitate reduction of the nominal pressure (please contact us).

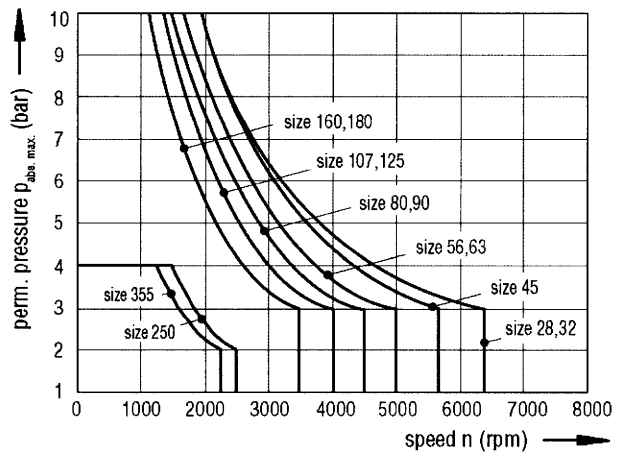
Sizes 250...355	
Nominal pressure p_N	350 bar
Peak pressure p_{max}	400 bar

With pulsating loads above 315 bar we recommend using the model with splined shaft, standart version A (sizes 28...180).

The summ of the pressures at ports A and B may not exceed 700 bar.

Case drain pressure
The lower the speed and the case drain pressure the higher the life expectation of the shaft seal ring.

Shaft seal ring **FPM** (fluor-caoutchouc)
The values shown in the diagram are permissible loads of the seal ring and shall not be exceeded.
At stationary pressure loads in the range of the max. admissible leakage pressure a reduction of the life experience of the seal ring will result.
For a short period (t < 5 min.) for the sizes 28...180 pressure loads up to 5 bar independent from rotational speeds are permissible.



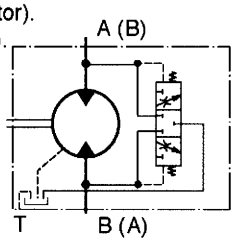
Special operation conditions may require limitations of these values.

Note:
- maximum permissible motor speeds are given in the table on page 5
- max. perm. casing pressure $p_{abs.\,max}$ – 10 bar (sizes 28...180)
  — 4 bar (sizes 250...355)
- the pressure in the housing must be the same as or greater than the external pressure on the shaft seal.

Integral flushing valve
In order to prevent excessive heat build-up in closed circuit operation, it is possible to fit a flushing valve (built into the port plate).
- switching pressure Δp ≥ 8 bar (this value is lower than the starting pressure of an unloaded motor).
- closed in centre position (Δp < 8 bar).

Sizes	23-32	45-63	80-90
Flushing-volume l/min	2,5	3,1	4,1

(values given for low pressure Δp = 25 bar)



Long-Life bearings (L) (sizes 250... 355)
(for high life expectancy and use of HF-fluids)

The outer dimensions of the axial piston motors are identical to standard design (without long life bearings). The change from standard design to long life bearing system is possible.

Table of values (theoretical values, without considering η_{mh} and η_v; values rounded)

Size			28	32	45	56	63	80	90	107	125	160	180	250	355
Displacement	V_g	cm³	28,1	32,0	45,6	56,1	63,0	80,4	90,0	106,7	125,0	160,4	180,0	250	355
Max. speed	n_{max}	rpm	6300	6300	5600	5000	5000	4500	4500	4000	4000	3600	3600	2500	2240
	$n_{max\ interm.}$ [1]	rpm	6900	6900	6200	5500	5500	5000	5000	4400	4400	4000	4000	–	–
Max. flow	$q_{V\,max}$	L/min	176	201	255	280	315	360	405	427	500	577	648	625	795
Torque constants	T_K	Nm/bar	0,445	0,509	0,725	0,89	1,0	1,27	1,43	1,70	1,99	2,54	2,86	3,98	5,64
Torque, Δp = 400 bar	T	Nm	178	204	290	356	400	508	572	680	796	1016	1144	1393 [2]	1976 [2]
Case volume		L	0,20	0,20	0,33	0,45	0,45	0,55	0,55	0,8	0,8	1,1	1,1	2,5	3,5
Moment of inertia	J	kgm²	0,0012	0,0012	0,0024	0,0042	0,0042	0,0072	0,0072	0,0116	0,0116	0,0220	0,0220	0,061	0,102
Weight (approx.)	m	kg	10,5	10,5	15	18	19	23	25	34	36	47	48	82	110

[1]) Intermittent max. speed: overspeed at discharge and overtaking travel operations, t < 5 sec. and Δp < 150 bar
[2]) Δp = 350 bar

Calculation of size

Flow $q_V = \dfrac{V_g \cdot n}{1000 \cdot \eta_v}$ in L/min

Output speed $n = \dfrac{q_V \cdot 1000 \cdot \eta_v}{V_g}$ in rpm

Output torque $T = \dfrac{V_g \cdot \Delta p \cdot \eta_{mh}}{20 \cdot \pi}$

$= \dfrac{1{,}59 \cdot V_g \cdot \Delta p \cdot \eta_{mh}}{100}$ in Nm

or $T = T_K \cdot \Delta p \cdot \eta_{mh}$ in Nm

Output power $P = \dfrac{2\pi \cdot T \cdot n}{60\,000} = \dfrac{T \cdot n}{9549}$

$= \dfrac{q_V \cdot \Delta p}{600} \cdot \eta_t$ in kW

V_g = geometric displacement per rev. in cm³
T = torque in Nm
Δp = pressure differential in bar
n = speed in rpm
T_K = torque constants in Nm/bar
η_v = volumetric efficiency
η_{mh} = mech.-hyd. efficiency
η_t = overall efficiency

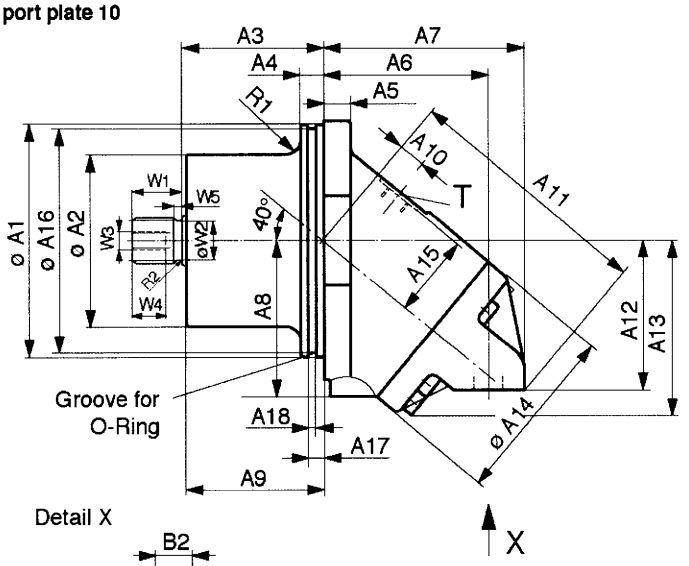
Preferred types, please state type and indent-no. when ordering

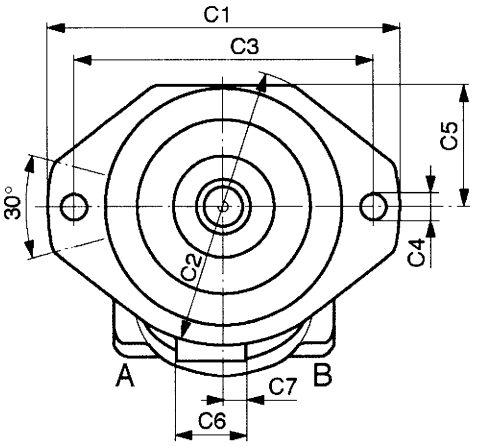
Type	Ident-No.	Type	Ident-No.
A2FE28/61W-NAL100	9419990	A2FE90/61W-NAL100	9416951
A2FE32/61W-NAL100	9418424	A2FE107/61W-NAL100	9419560
A2FE45/61W-NZL100	9437748	A2FE125/61W-NAL100	9418426
A2FE56/61W-NAL100	9437482	A2FE160/61W-NAL100	9421900
A2FE63/61W-NAL100	9437443	A2FE180/61W-NAL100	9421394
A2FE80/61W-NAL100	9419867		

sizes 28...180: production plant Elchingen; sizes 250...355: production plant Horb

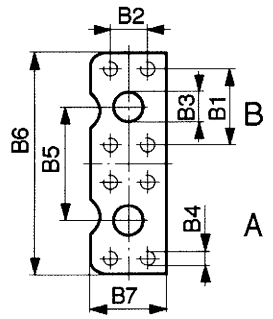
Unit Dimension, Sizes 28...180

port plate 10





Detail X



Connections

A, B	service line ports SAE 420 bar (6000 psi) high pressure series
T	drain port

Size	C1	ØC2	C3	C4	C5	C6	C7
28, 32	188	154	160	14	71	42	12,5
45	235	190	200	18	82	47,5	15
56, 63	235	190	200	18	82	36	0
80, 90	260	220	224	22	98	40	0
107, 125	286	232	250	22	103	40	0
160, 180	286	232	250	22	104	42	0

Size	ØA1	ØA2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	ØA14	A15	A16	A17	A18
28, 32	135_{h6}	94±1,5	88,8	15	16	94	114	95	87,1	19	149	91	106	106	51,5	128,7	10	5,2
45	160_{h6}	$117^{+1,5}_{-2}$	92,3	15	18	109	133	106	90	18	167	102	119	118	56	153,7	10	5,2
56, 63	160_{h6}	121–0,5	92,3	15	18	122	146	109	90	18	176	107	130	128	59	153,7	10	5,2
80, 90	190_{h6}	139±1,3	110,8	15	20	127	157	123	106	15	198	121	145	138	66	183,7	10	5,2
107, 125	200_{h6}	151±1,3	122,8	15	20	143	178	135	119	18	224	136	157	150	69	193,7	10	5,2
160, 180	200_{h6}	170±1,6	122,8	15	20	169	211	134	119,3	19,5	244	149	188	180	78	193,7	10	5,2

Size	R1	O-Ring[1])	B1	B2	ØB3	B4 Threads	B5	B6	B7	Port A, B	Drain ports T
28, 32	10	126x4	40,5	18,2	13	M8; 15 deep	59	115	40	SAE 1/2"	M16x1,5; 12 deep
45	10	150x4	50,8	23,8	19	M10; 17 deep	75	147	49	SAE 3/4"	M18x1,5; 12 deep
56, 63	10	150x4	50,8	23,8	19	M10; 17 deep	75	147	49	SAE 3/4"	M18x1,5; 12 deep
80, 90	10	180x4	57,2	27,8	25	M12; 17 deep	84	166	60	SAE 1"	M18x1,5; 12 deep
107, 125	16	192x4	66,7	31,8	32	M14; 19 deep	99	194	70	SAE 1 1/4"	M22x1,5; 12 deep
160, 180	12	192x4	66,7	31,8	32	M14; 19 deep	99	194	70	SAE 1 1/4"	M22x1,5; 12deep

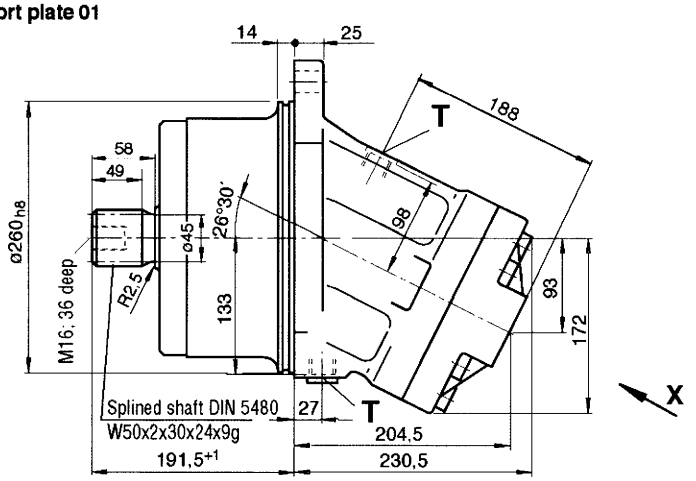
[1]) The O-ring is not comprised in the delivery volume!

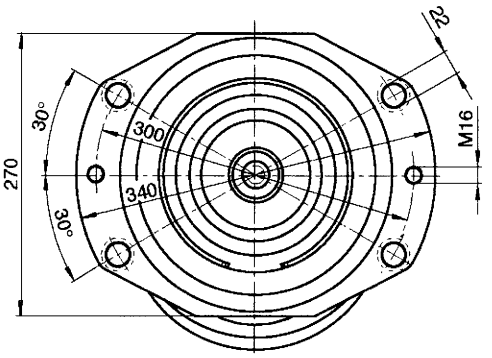
Size	Shaft end (DIN 5480)	W1	ØW2	W3	W4	W5	R2
28, 32	**A** W 30x2x30x14x9g	35,2	24,6	M10	22	8	1,6
28	**Z** W 25x1,25x30x18x9g	43,2	21,6	M8	19	15	1,6
45	**A** W 32x2x30x14x9g	35	26,6	M12	28	8	1,6
	Z W 30x2x30x14x9g	35	24,6	M12	28	8	1,6
56, 63	**A** W 35x2x30x16x9g	40	29,6	M12	28	8	1,6
	Z W 30x2x30x14x9g	35	24,6	M12	28	8	1,6

Size	Shaft end (DIN 5480)	W1	ØW2	W3	W4	W5	R2
80, 90	**A** W 40x2x30x18x9g	45	34,6	M16	36	8	2,5
	Z W 35x2x30x16x9g	40	29,6	M12	28	8	1,6
107, 125	**A** W 45x2x30x21x9g	50	39,6	M16	36	8	2,5
	Z W 40x2x30x18x9g	45	34,6	M12	28	8	2,5
160, 180	**A** W 50x2x30x24x9g	55	44,6	M16	36	11	4
	Z W 45x2x30x21x9g	50	39,6	M16	36	8	2,5

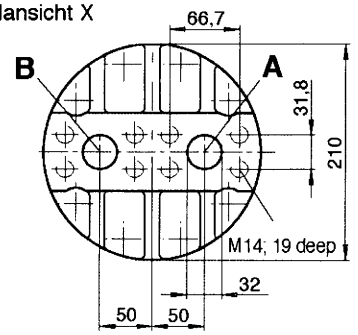
Unit Dimensions, Size 250

port plate 01





Teilansicht X

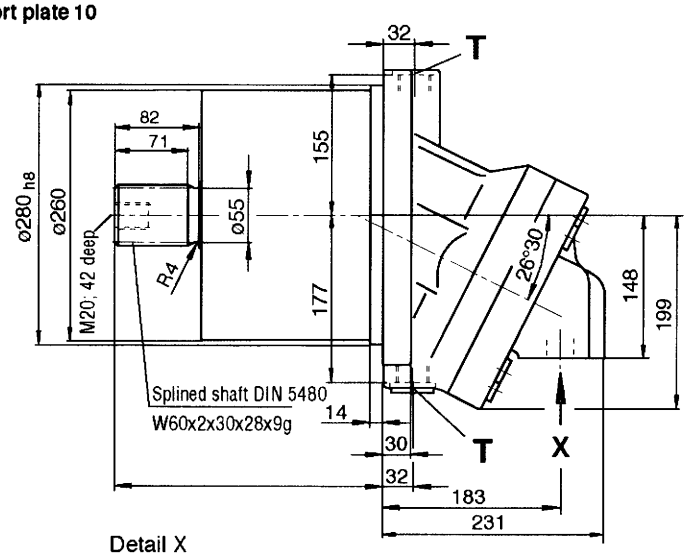


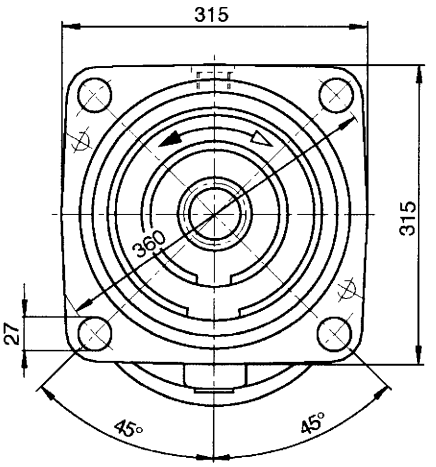
Connections

A, B	service line ports 420 bar (6000 psi) high pressure series	SAE 1 ¼"
T	drain ports (1 port plugged)	M22x1,5

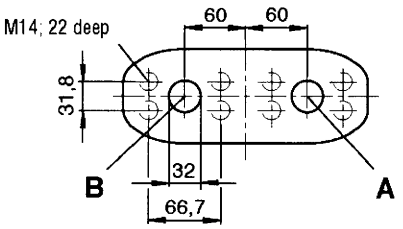
Unit Dimensions, Size 355

port plate 10





Detail X



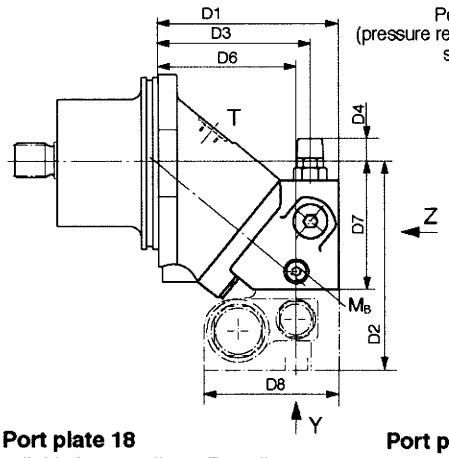
Connections

A, B	service line ports 420 bar (6000 psi) high pressure series	SAE 1 ¼"
T_1,T_2	drain ports (1 port plugged)	M33x2

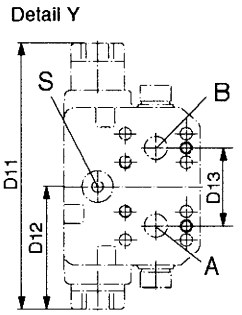
Fixed Displacement Plug-In Motor A2FE

Before finalising your design, please request a certified drawing.
Subject to revision.

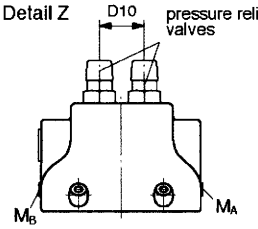
Port plate 17, 18 with integrated pressure relief valves, for mounting a motion control valve

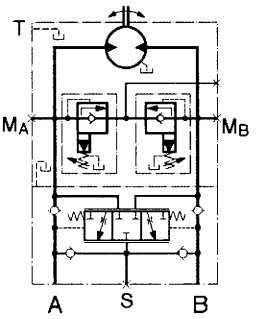


Port plate 171, 181
(pressure relief valves *without* pressure sequence range)



Detail Z





Port plate 18
suitable for mounting a Rexroth motion control valve (see RE 64317):
MHB**16**....18 (A2FM 28, 32, 45)
MHB**16**....18E (A2FM 56, 63)
MHB**20**....11 (A2FM 56, 63)
MHB**20**....18 (A2FM 80, 90)
MHB**25**....18 (A2FM 107, 125, 160, 180)

Port plate 17
suitable for mounting a Rexroth motion control valve (see RE 64317):
MHB**20**....18E (A2FM 107, 125)

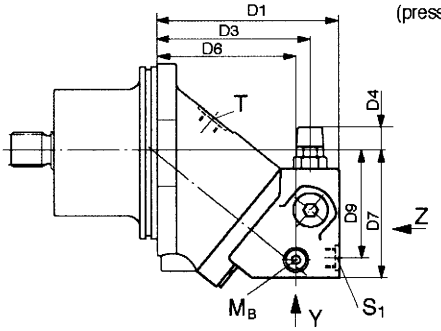
Connections

A, B	service line ports SAE, 420 bar (see table below) (6000 psi high pressure series)	
S	boosting	(see table below)
M_A,M_B	test ports (plugged)	M12x1,5

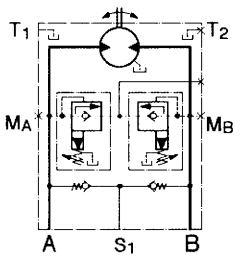
The motion control valve is not included in the ordering code and has to be indicated separately.

We recommend total supply through Brueninghaus Hydromatik.

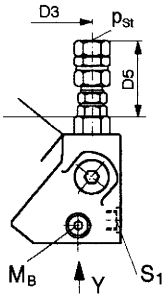
Port plate 19, with integrated pressure relief valves

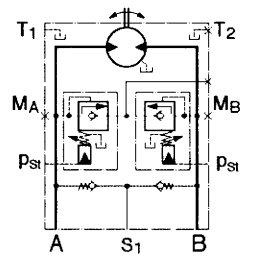


Port plate 191
(pressure relief valves *without* pressure sequence range)

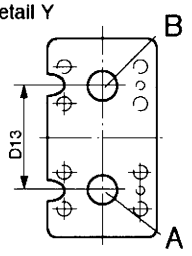


Port plate 192
(pressure relief valves *with* pressure sequence range)

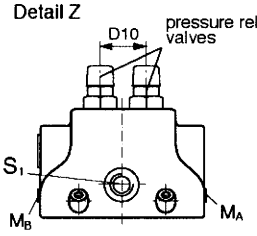




Detail Y



Detail Z



Connections

A, B	service line ports SAE, 420 bar (see table below) (6000 psi high pressure series)	
S_1	boosting	(see table below)
p_{St}	pilot pressure port	G 1/4
M_A, M_B	test ports (plugged)	M20x1,5 (Sizes 28...45) M26x1,5 (Sizes 56...125) M30x1,5 (Sizes 160...180)

Pressure relief valves

-without pressure sequence range (1)	*-with* pressure sequence range (2)
MHDBN**16** (Sizes 28...45)	MHDBB**16** (Sizes 28...45)
MHDBN**22** (Sizes 56...90)	MHDBB**22** (Sizes 56...90
MHDBN**32** (Sizes 107...180)	MHDBB**32** (Sizes 107...180)

Size		D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	Ports A, B	Port S	Port S_1
28, 32		145	170	127	25	63	110	102	115	87	36	215,5	93,5	66	SAE 3/4"	M 18x1,5	M 22x1,5
45		161	181	136	22	60	126	113	115	98	36	215,5	93,5	66	SAE 3/4"	M 18x1,5	M 22x1,5
56, 63	*(+MHB16)*	189	192	162	19	57	147	124	115	105	42	215,5	93,5	75	SAE 3/4"	M 18x1,5	M 26x1,5
	(+MHB20)	189	192	162	29	57	147	124	137	105	42	235	96	75	SAE 3/4"	M 22x1,5	M 26x1,5
80, 90		193	202	165	17,5	55	151	134	137	114	42	235	96	75	SAE 1"	M 22x1,5	M 26x1,5
107, 125	*(+MHB20)*	216	217,5	184	10	48	168	149,5	137	130	53	286	120,5	84	SAE 1"	M 27x2	M 26x1,5
	(+MHB25)	216	234,5	184	10	48	168	149,5	151,5	130	53	286	120,5	84	SAE 1 1/4"	M 27x2	M 26x1,5
160, 180		253	255	222	5	—	204	170	151,5	149	53	286	120,5	84	SAE 1 1/4"	M 27x2	M 26x1,5

Brueninghaus Hydromatik GmbH, Plant Elchingen, Glockeraustraße 2, D–89275 Elchingen, Tel. (07308) 820, Telefax (07308) 7274
Plant Horb, An den Kelterwiesen 14, D–72160 Horb, Tel. (07451) 920, Telefax (07451) 8221

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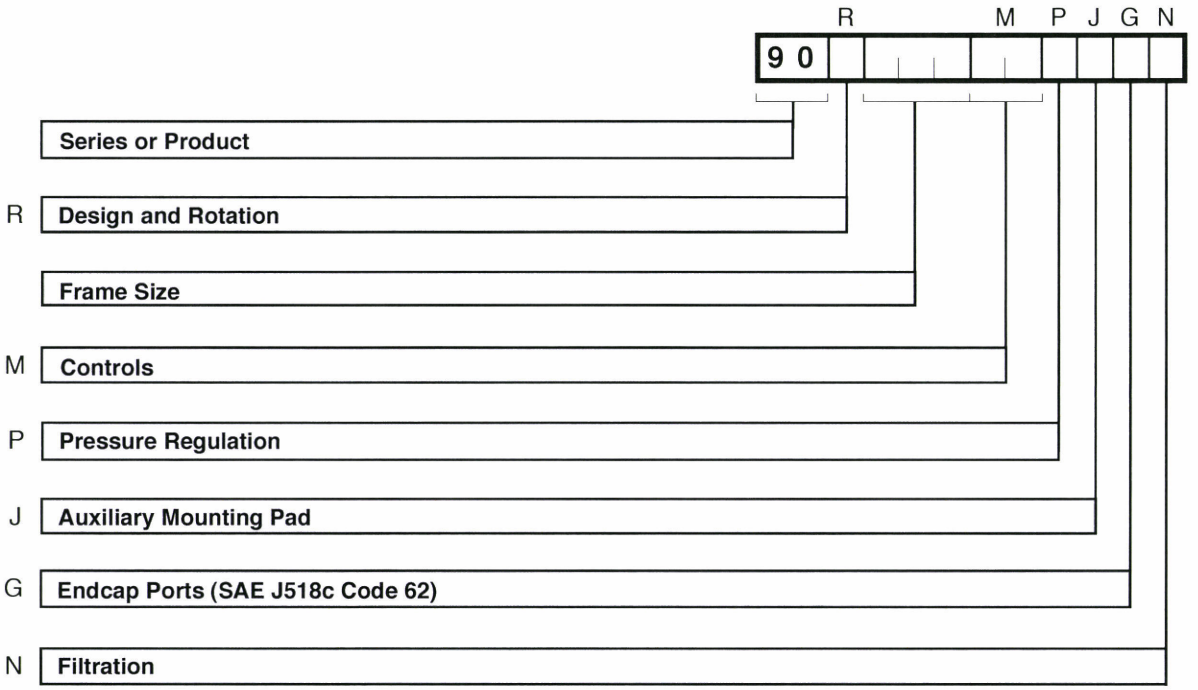
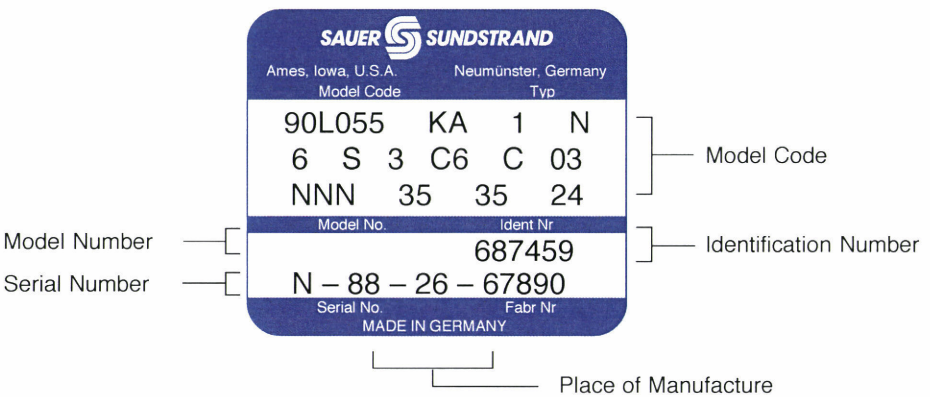
Type Designation and Order Code

Refer to Model Code Supplement or Price List for available options and applicable ordering codes.

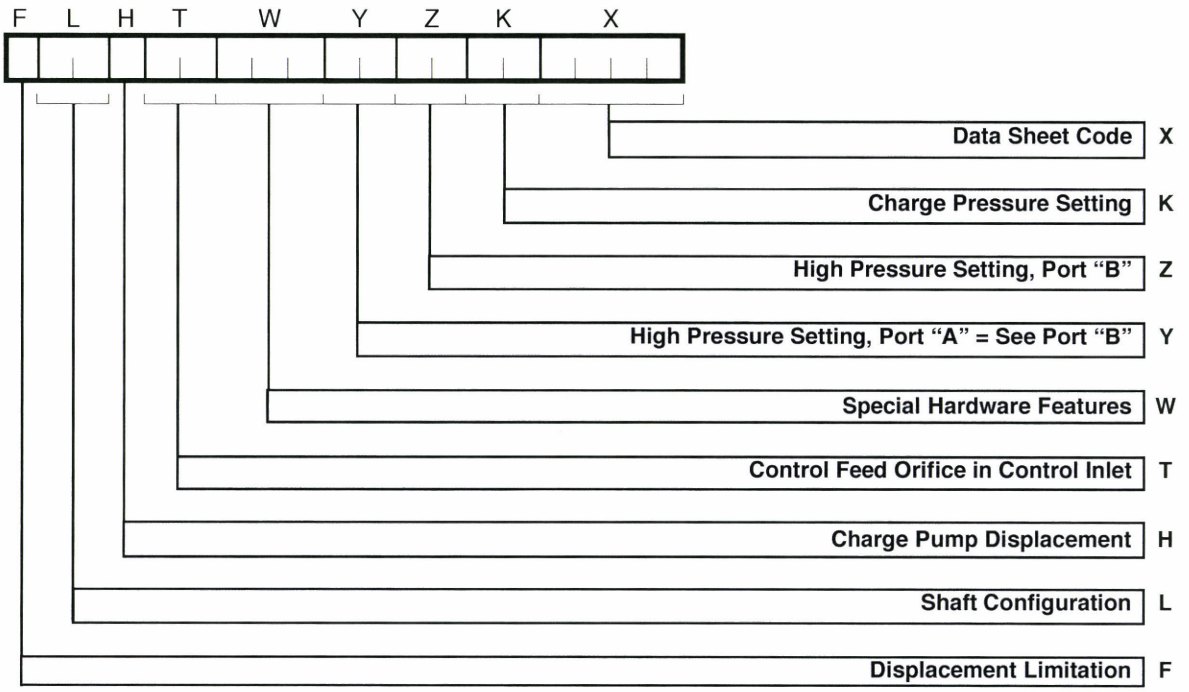


Name Plate

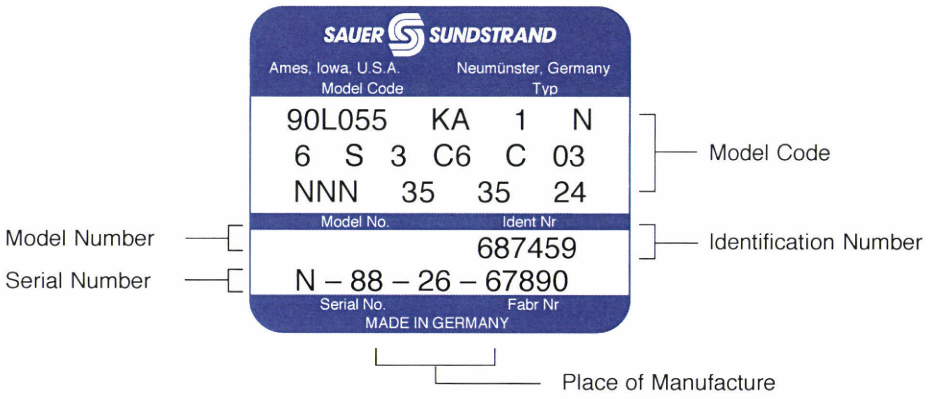


Type Designation and Order Code (Continued)

Refer to Model Code Supplement or Price List for available options and applicable ordering codes.



Name Plate

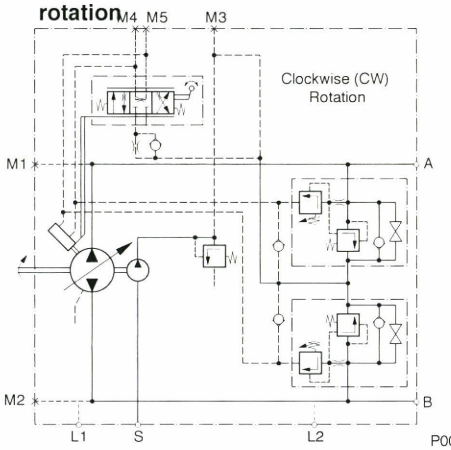


Technical Specifications - Variable Displacement Pump

Circuit Diagram and Nomenclature

Variable displacement pump

Figure 3: Variable displacement pump with charge pump and manual displacement control MA, clockwise rotation



Ports:

A, B	=	Main pressure lines
S	=	Suction line - charge pump
L1, L2	=	Case drain lines
M1, M2	=	Gauge port for port "A" and "B"
M3	=	Gauge port - charge pressure
M4, M5	=	Gauge port - servo pressure

Design

Axial piston pump of cradle swashplate design with variable displacement.

Type of Mounting

SAE flange, Size B, C, D, E (SAE J 744) mounting pad

Pipe Connections

Main pressure ports: SAE-Flange Twin ports, radial (all Frame Sizes)
SAE-Flange Side ports, radial (055 / 075 / 100)
Remaining ports: SAE straight thread O-ring boss

Direction of Rotation

Clockwise or counterclockwise (unidirectional).

Installation Position

Pump installation recommended with control position on the top or side. Consult SAUER-SUNDSTRAND for non-conformance guidelines. The housing must always be filled with hydraulic fluid.

Flow Direction

See pages 25, 27, 28, 30, and 31.

Hydraulic Parameters

System Pressure Range, Input p_1 (see page 12)

Variable displacement pump:
Charge pressure = see order code on page 9
Charge pump input pressure:
Min. rated pressure = 0,7 bar (20,6 in Hg) absolute
Min. allowable pressure, intermittent = 0,2 bar (5,9 in Hg) absolute

System Pressure Range, Output p_2 (see page 12)

Rated pressure :	420 bar	(6 000 psi)	
Max. Pressure :	480 bar	(7 000 psi)	

Case Pressure (see page 12)

Max. Rated:	3 bar	(40 psi)	
Intermittent pressure:	5 bar	(75 psi)	Cold start

Hydraulic Fluid (see page 12)

Refer to SAUER-SUNDSTRAND publication, BLN-9887 or 697581. Refer to ATI-9101E for information relating to biodegradable fluids.

Temperature Range[1] (see page 12)

ϑ min	=	- 40 °C	(- 40 °F)	intermittent, cold start
ϑ nenn	=	104 °C	(220 °F)	
ϑ max	=	115 °C	(240 °F)	intermittent

at the hottest point, e.g. drain line
[1] Hydraulic fluid viscosity has to be considered

Fluid Viscosity Limits

mm^2/s (1 mm^2/s = 1 cSt)			SUS (Saybolt Universal Second)
ν min	=	7	47 intermittent
ν nenn	=	12 - 60	66 - 278 rated viscosity
ν max	=	1 600	7 500 intermittent, cold start

Filtration

Required cleanliness level: ISO 4406 Code 18/13 or better.
Refer to SAUER-SUNDSTRAND publication
BLN-9887 or 697581 and ATI-9201E.

82

Technical Data

Table 1

		Dimension	Frame Size 030	042	055	075	100	130	180	250
Displacement		**cm^3**	**30**	**42**	**55**	**75**	**100**	**130**	**180**	**250**
		in^3	1.83	2.56	3.35	4.57	6.10	7.93	10.98	15.25
Input speed	Minimum	min^{-1} (rpm)	500	500	500	500	500	500	500	500
	Rated *	min^{-1} (rpm)	4 200	4 200	3 900	3 600	3 300	3 100	2 600	2 300
	Maximum *	min^{-1} (rpm)	4 600	4 600	4 250	3 950	3 650	3 400	2 850	2 500
	Max. Attainable *	min^{-1} (rpm)	5 000	5 000	4 700	4 300	4 000	3 700	3 150	2 750
Theoretical Torque		**Nm/bar**	**0,48**	**0,67**	**0,88**	**1,19**	**1,59**	**2,07**	**2,87**	**3,97**
		in lb/1000 psi	290	410	530	730	970	1 260	1 750	2 433
Mass moment of inertia of the int. rotating parts		**kg m^2**	**0,0023**	**0,0039**	**0,0060**	**0,0096**	**0,0150**	**0,023**	**0,0380**	**0,0650**
		lb • ft^2	0.0546	0.0926	0.1424	0.2278	0.3560	0.5460	0.9020	1.5430
Weight (with MA Control)		**kg**	**28**	**34**	**40**	**49**	**68**	**88**	**136**	**154**
		lb	62	75	88	108	150	195	300	340

* General Technical Specifications, see page 12

Determination of Nominal Pump Size

Inch-System:

Pump output flow: $Q = \frac{PD \cdot PS \cdot EV}{231}$ gpm

Input torque: $PT = \frac{PD \cdot p}{2 \cdot \pi \cdot ET}$ lbf•in

Input power: $p = \frac{PD \cdot PS \cdot p}{396\,000 \cdot ET}$ hp

Metric-System:

Pump output flow: $Qe = \frac{Vg \cdot n \cdot \eta_v}{1\,000}$ l/min

Input torque: $Me = \frac{Vg \cdot \Delta p}{20 \cdot \pi \cdot \eta_{mh}}$ Nm

Input power: $Pe = \frac{Me \cdot n}{9\,550} = \frac{Qe \cdot \Delta p}{600 \cdot \eta_t}$ kW

Description:

Inch-System:

PD	=	Pump displacement per rev.	in^3
PS	=	Hydrostatic pump speed	rpm
p	=	Differential hydraulic pressure	psi
EV	=	Pump volumetric efficiency	
ET	=	Pump mechanical - hydraulic (Torque) efficiency	

Metric-System:

Vg	=	Pump displacement per rev.	cm^3
Δp	=	pHD - pND	bar
η_v	=	Pump volumetric efficiency	
η_{mh}	=	Pump mechanical -	

Dimensions · Controls (Continued)

Figure 48: Electric Displacement Control (EDC) with MS-Connector or Packard-Connector

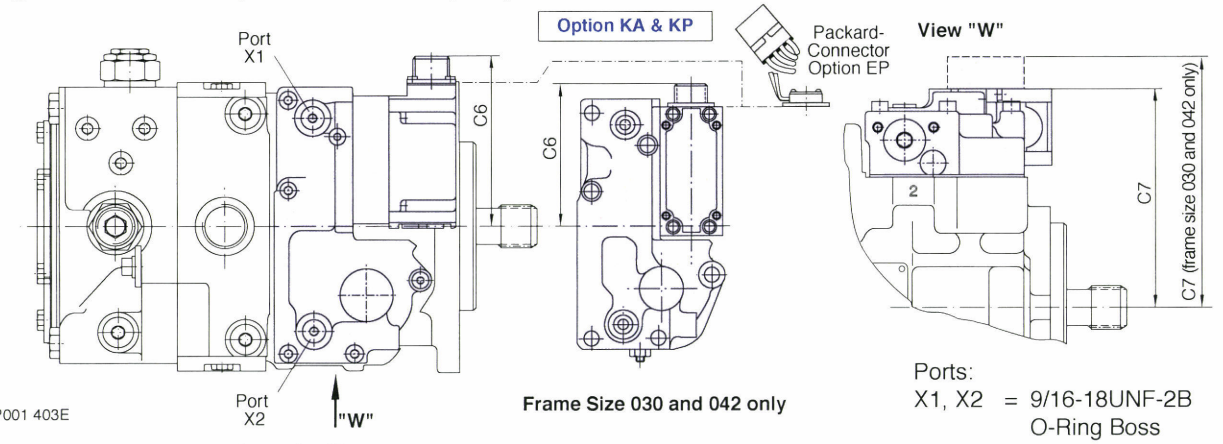


Table 24: Dimensions [mm (in.)]

Frame Size	C6	C7
030	95,3 (3.75)	173,5 (6.83)
042	95,3 (3.75)	173,5 (6.83)
055	95,3 (3.75)	141,2 (5.56)
075	105,2 (4.14)	144,8 (5.70)
100	114,0 (4.49)	153,7 (6.05)
130	99,1 (3.90)	172,7 (6.80)
180 / 250	93,4 (3.68)	190,0 (7.48)

Figure 49: Hydraulic Displacement Control (HDC)

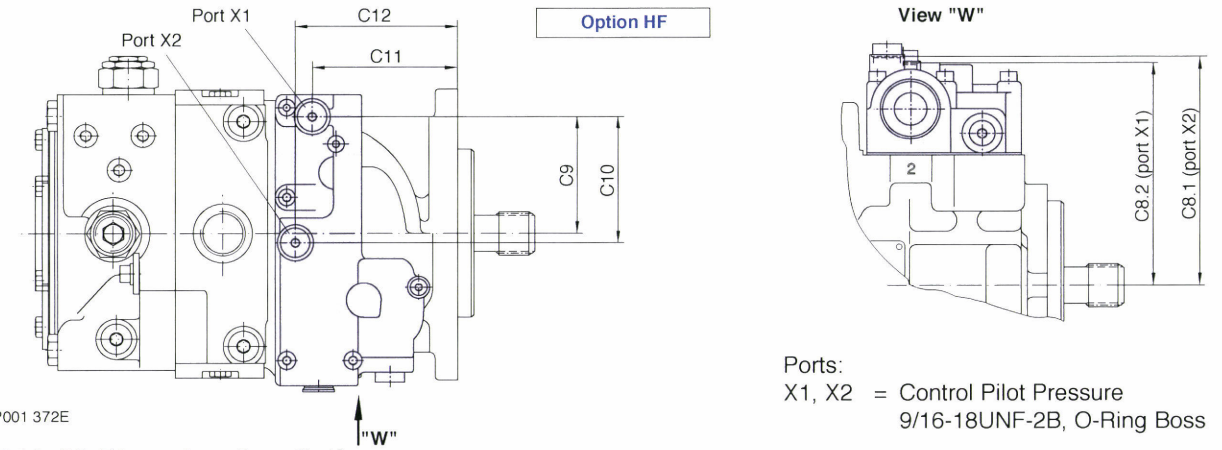


Table 25: Dimensions [mm (in.)]

Frame Size	C8.1	C8.2	C9	C10	C11	C12
030	135,0 (5.31)	131,0 (5.15)	71,0 (2.79)	75,7 (2.98)	77,6 (3.05)	87,2 (3.43)
042	139,0 (5.47)	135,0 (5.31)	71,0 (2.79)	75,7 (2.98)	89,6 (3.52)	99,2 (3.90)
055	143,0 (5.63)	139,0 (5.47)	71,0 (2.79)	75,7 (2.98)	105,6 (4.15)	115,2 (4.53)
075	148,9 (5.86)	139,9 (5.50)	68,2 (2.68)	67,0 (2.63)	121,8 (4.79)	125,3 (4.93)
100	158,0 (6.22)	149,0 (5.86)	76,8 (3.02)	67,0 (2.63)	127,9 (5.03)	131,4 (5.17)
130	176,7 (6.95)	167,7 (6.60)	61,8 (2.43)	67,0 (2.63)	142,1 (5.59)	145,6 (5.73)
180 / 250	194,0 (7.63)	185,0 (7.28)	54,0 (2.12)	67,0 (2.63)	148,6 (5.85)	152,1 (5.99)

Model Code

A specific model can be designated by generating a modular Model Code. The Model Code must be designated in the sequence shown here.

LEGEND:
● = Standard
○ = Optional
- = Not Available

		M	P	J	G	N	F	L	H	T	W	Y	Z	K
9	0													

Frame Size

042	055	075	100	130	180	250
●	●	●	●	●	●	●

PRODUCT
90 = Series 90

DESIGN & ROTATION
L = Pump, Left Hand Rotation (CCW)
R = Pump, Right Hand (CW)

FRAME SIZE

●	-	-	-	-	-	-
-	●	-	-	-	-	-
-	-	●	-	-	-	-
-	-	-	●	-	-	-
-	-	-	-	●	-	-
-	-	-	-	-	●	-
-	-	-	-	-	-	●

042 = 42.0 cm³/rev (2.56 in³/rev)
055 = 55.0 cm³/rev (3.35 in³/rev)
075 = 75.0 cm³/rev (4.57 in³/rev)
100 = 100.0 cm³/rev (6.10 in³/rev)
130 = 130.0 cm³/rev (7.93 in³/rev)
180 = 180.0 cm³/rev (10.99 in³/rev)
250 = 250.0 cm³/rev (15.25 in³/rev)

M: CONTROLS

○	○	○	○	○	○	○
○	○	○	○	○	-	-
○	○	○	○	-	-	-
○	○	○	○	○	○	○
○	○	○	○	○	-	-
-	○	○	○	-	-	-
○	○	○	○	○	○	○
○	○	○	○	○	○	○
●	●	●	●	●	●	●
○	○	○	○	○	○	○
○	○	○	○	○	-	-
○	○	○	○	○	-	-
-	-	○	○	○	-	-
-	○	○	○	○	-	-
○	○	○	○	○	○	○

CB = Cover Plate w/ Feedback Link
DC = Electric 3-Position (FNR) Solenoid (12 VDC)
DD = Electric 3-Position (FNR) Solenoid (24 VDC)
HF = Hydraulic Displacement (HDC) 3-11 bar (44-160 psi)
HM = Hydraulic Displacement (HDC) 1.1-6.7 bar (16-97 psi)
HS = Hydraulic Displacement (HDC) 6-18 bar (87-261 psi)
KA = Electric Displacement (EDC) MS-Connector
KP = Electric Displacement (EDC) Packard-Connector
MA = Manual Displacement (MDC)
MB = Manual Displacement w/ Neutral Start Switch (NSS)
MD = Manual Displacement w/ NSS and DC Solenoid Override, 12V DC
MC = Manual Displacement w/DC Solenoid Override, 12V DC
MT = Manual Displacement w/ 12V DC Solenoid Override (2 Pole)
MV = Manual Displacement w/ NSS (Weather-Pack Connector)
NA = Non-Linear Manual Displacement

P: PRESSURE REGULATION

●	●	●	●	●	●	●
○	○	○	○	○	○	○

1 = Pressure Limiter (PL) in Port "A" and "B"
2 = High Pressure Relief Valve only - No Pressure Limiter

J: AUXILIARY MOUNTING PAD

○	○	○	○	○	○	○
○	○	○	○	○	○	○
○	○	○	○	○	○	○
○	○	○	○	○	○	○
-	○	○	○	○	○	○
-	-	-	-	○	○	○
-	-	-	-	-	○	○
-	-	-	-	-	○	○
○	○	○	○	○	○	○
●	●	●	●	●	●	●

AB = SAE A w/ Sealed Cover (9 Teeth, 16/32 Pitch)
AD = SAE A w/ Sealed Cover (9 Teeth, 16/32 Pitch)
BC = SAE B w/ Sealed Cover (13 Teeth, 16/32 Pitch)
BG = SAE B w/ Sealed Cover (13 Teeth, 16/32 Pitch)
CD = SAE C w/ Sealed Cover (14 Teeth, 12/24 Pitch)
DE = SAE D w/ Sealed Cover (13 Teeth, 8/16 Pitch)
EF = SAE E w/ Sealed Cover (13 Teeth, 8/16 Pitch)
EG = SAE E w/ Sealed Cover (27 Teeth, 16/32 Pitch)
BB = SAE B-B w/ Sealed Cover (15 Teeth, 16/32 Pitch)
NN = No Auxiliary Mounting Pad

G: ENDCAP PORTS (SAE J518C CODE 62)

-	●	●	●	-	-	-
●	●	●	●	●	●	●

60 = Side Ports
80 = Twin Ports, Radial

LEGEND:
● = Standard
○ = Optional
- = Not Available

		M	P	J	G	N	F	L	H	T	W	Y	Z	K
9	0													

Frame Size

042	055	075	100	130	180	250
●	●	●	●	●	●	●
○	○	○	○	○	-	-
○	○	○	○	○	-	-
○	○	○	○	○	-	-
-	-	-	-	-	○	○
○	○	○	○	○	○	-

N: FILTRATION

S	=	Suction Filtration
R	=	Remote Pressure - w/o Filter
P	=	Integral Pressure Filter - w/ Spin-on Filter (Short)
L	=	Integral Pressure Filter - w/ Spin-on Filter (Long)
T	=	Remote Pressure - w/o Filter
D	=	Suction Filtration for No Charge Pump Option

●	●	●	●	●	●	●
○	○	○	○	○	○	○

F: DISPLACEMENT LIMITATION

3	=	No Displacement Limiters
4	=	Displacement Limiters on Both Sides (Factory Set to Maximum Disp.)

●	-	-	-	-	-	-
○	-	-	-	-	-	-
-	○	○	-	-	-	-
-	-	○	○	-	-	-
-	-	-	-	○	○	○
-	-	-	●	●	●	●
-	○	-	-	-	-	-
-	-	○	-	-	-	-
-	-	-	○	-	-	-
-	●	●	○	-	-	-
-	○	○	-	-	-	-
-	-	○	○	-	-	-
○	-	-	-	-	-	-
-	-	-	-	○	-	-

L: SHAFT CONFIGURATION

C3	=	15 Teeth, 16/32 Pitch
C5	=	19 Teeth, 16/32 Pitch
C6	=	21 Teeth, 16/32 Pitch
C7	=	23 Teeth, 16/32 Pitch
C8	=	27 Teeth, 16/32 Pitch
F1	=	13 Teeth, 8/16 Pitch
K1	=	1.375 in. Str. Key
K2	=	1.500 in. Str. Key
K3	=	1.750 in. Str. Key
S1	=	14 Teeth, 12/24 Pitch
T1	=	1.375 in. Tapered
T2	=	1.500 in. Tapered
T3	=	1.000 in. Tapered
T4	=	1.750 in. Tapered

○	-	-	-	-	-	-
●	○	-	-	-	-	-
○	●	○	-	-	-	-
-	○	●	○	-	-	-
-	-	○	●	○	-	-
-	-	-	○	●	-	-
-	-	-	-	○	●	-
-	-	-	-	-	○	●
-	-	-	-	-	-	○
○	○	○	○	○	○	-

H: CHARGE PUMP DISPLACEMENT

A	=	8 cm³ (0.50 cu. in./Rev.)
B	=	11 cm³ (0.69 cu. in./Rev.)
C	=	14 cm³ (0.86 cu. in./Rev.)
D	=	17 cm³ (1.03 cu. in./Rev.)
E	=	20 cm³ (1.20 cu. in./Rev.)
F	=	26 cm³ (1.60 cu. in./Rev.)
H	=	34 cm³ (2.07 cu. in./Rev.)
J	=	47 cm³ (2.82 cu. in./Rev.)
K	=	65 cm³ (3.90 cu. in./Rev.)
L	=	External Charge Pump w/ Internal Relief Valve

○	○	○	○	○	○	○
○	○	○	○	○	○	○
○	○	○	○	○	○	○
●	●	●	●	●	●	●
○	○	○	○	○	○	○
○	○	○	○	○	○	○
○	○	○	○	○	○	○
○	○	○	○	○	○	○

T: CONTROL FEED ORIFICE IN CONTROL INLET

00	=	No Orifice
01	=	ø 0.46 mm (.018 in. Dia.)
02	=	ø 0.66 mm (.026 in. Dia.)
03	=	ø 0.81 mm (.032 in. Dia.)
04	=	ø 1.02 mm (.040 in. Dia.)
05	=	ø 1.37 mm (.054 in. Dia.)
06	=	ø 1.57 mm (.062 in. Dia.)
09	=	ø 2.34 mm (.092 in. Dia.)

LEGEND:
● = Standard
○ = Optional
- = Not Available

		M	P	J	G	N	F	L	H	T	W	Y	Z	K
9	0													

042	055	075	100	130	180	250

Frame Size

-	-	-	-	-	●	●
○	○	○	○	○	-	-
-	○	○	○	-	-	-
-	-	-	-	○	-	-

W: SPECIAL HARDWARE FEATURES

NNN = None
GBA = Low Noise Valve Plate
EBC = Speed Sensor (KPPE13408*)
EBA = Speed Sensor (KPPE13408*)

***NOTE:** KPPE13408 USES SUPPLY VOLTAGE OF 4.5-15 VOLTS. DO NOT POWER DIRECTLY FROM A BATTERY BECAUSE OF VOLTAGE TRANSIENTS (VOLTAGE SPIKES ABOVE 15V)
Reference PIB-9602M, Pulse Pickup Bulletin for more information and options.

○	○	○	○	○	○	○
○	○	○	○	○	○	○
○	○	○	○	○	○	○
○	○	○	○	○	○	○
○	○	○	○	○	○	○
○	○	○	○	○	○	○
○	○	○	○	○	○	○
○	○	○	○	○	○	○
○	○	○	○	○	○	○
○	○	○	○	○	○	○

Y/Z: HIGH PRESSURE SETTING, PORT "A" & "B"

00 = No Pressure Regulating Valves
14 = 140 Bar (2030 psi)
17 = 170 Bar (2460 psi)
20 = 200 Bar (2900 psi)
23 = 230 Bar (3330 psi)
26 = 260 Bar (3770 psi)
29 = 290 Bar (4200 psi)
32 = 320 Bar (4640 psi)
35 = 350 Bar (5070 psi)
38 = 380 Bar (5510 psi)
42 = 420 Bar (6090 psi)

○	○	○	○	○	○	○
○	○	○	○	○	○	○
●	●	●	●	●	●	●
○	○	○	○	○	○	○

K: CHARGE PRESSURE SETTING

18 = 18 Bar (260 psi)
20 = 20 Bar (290 psi)
24 = 24 Bar (350 psi)
28 = 28 Bar (410 psi)

DURST USA.COM

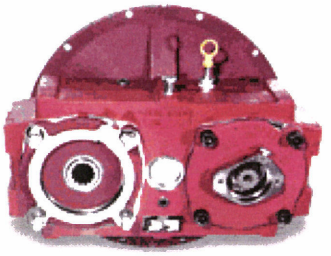
Products/Applications

Helidraulic Pump Drive

Select Product

FEATURES

- Compact High Strength Cast Iron Housing
- Spur and Helical High Capacity Gearing
- Tapered Rolling Bearings
- Double Lip Spring - Loaded Oil Seals
- Reducer or Increaser Application
- Hollow Shaft or Hydraulic Flange Mounts Available



APPLICATIONS

- Construction
- Agricultural
- Offshore Oil
- Forestry
- Marine Decking
- Material Handling
- Railway Maintenance

PUMP DRIVE QUICK SELCTION GUIDE

			RATIOS	
MODEL	**RATING H.P.**	**WEIGHT**	DECREASERS	INCREASERS
1751D	490 @ 2500	85-125	Direct 1:1	Direct 1:1
KF89	490 @ 2500	125-220	1, 1.15, 1.23, 1.31, 1.41, 1.51, 1.67:1	1:1.15, 1.23, 1.31 1.41, 1.51, 1.67
KD01	352 @ 2500	180 - 295	1, 1.11, 1.25, 1.43 1.62:1	1:1.11, 1.25, 1.43
KF01	460 @ 2500	195 - 345	1, 1.15, 1.23, 1.31, 1.41, 1.51, 1.68:1	1:1.15, 1.23, 1.31, 1.41, 1.51, 1.68
KF45	490 @ 2500	305 - 485	1, 1.1, 1.19, 1.29, 1.39:1	1:1.1, 1.19, 1.29, 1.39
KJ45	675 @ 2500	370 - 485	1, 1.1, 1.19, 1.29, 1.39:1	1:1.1, 1.19, 1.29, 1.39
KJ23	675 @ 2500	335 - 440	1, 1.1, 1.19, 1.29, 1.39:1	1:1.1, 1.19, 1.29, 1.39

Note: Refer to warning, safety, and installation manual before installling or operating power transmission products. Contact Us for Installation Manuals.

Application Data Form

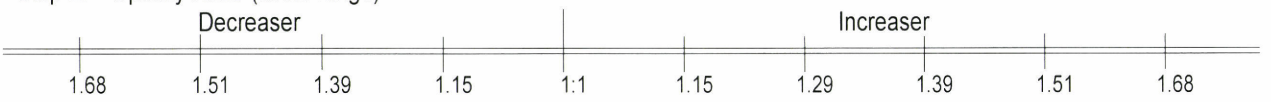
DURST
A Division of Regal-Beloit Corporation
Buss Road • Shopiere, WI 53525
1-800-356-0775 608-365-2563
Fax: 608-365-2182
sales@durstusa.com

APPLICATION DATA

Step 1.

2 Pad	3 Pad	4 Pad	Single Pad
KD ❑ KF ❑	KF ❑ KJ ❑	KJ ❑ KL ❑	UD1 ❑ KF ❑

Step 2. Specify Ratio (circle range)



Step 3. Style 01 (Drive Plate)

A. ❑ SAE 8 in. ❑ SAE 10 in. ❑ SAE 11½ ❑ SAE 14 in. ❑ Other _____

B. Specify flywheel pilot diameter
❑ 2.04 in. ❑ 2.44 in. ❑ 2.83 in. ❑ 3.15 in. ❑ Special

C. Specify engine housing
❑ SAE #1 ❑ SAE #2 ❑ SAE #3 ❑ SAE #4 ❑ Other _____

Step 4. Style 04 (Independent Input)

A. Specify Input Option:

1. ❑ Companion Flange
Spicer 1480/1550/1610

2. ❑ Companion Flange
Spicer 1350/1410

3. ❑ Keyed Shaft
2¼ dia. W/.5 keyway 1221-113
2 dia. W/.5 keyway 1257-161

4. ❑ Tractor PTO–540 RPM
w/locking groove 1232-104

5. ❑ Splined Shaft
13T 8/16 involute 1221-107

6. ❑ Tractor PTO–540 RPM
1221-112

Step 5. For Style 21 Clutch Coupled Input

A. Specify SAE clutch size component package:

1. ❑ SAE 10 in. single plate
2. ❑ SAE 11½ in. single plate
3. ❑ SAE 11½ in. double plate
4. ❑ SAE 14 in. single plate
5. ❑ SAE 14 in. double plate
6. ❑ Other _____

B. Specify SAE clutch housing size:
❑ SAE #1 ❑ SAE #2 ❑ SAE #3 ❑ SAE #4

C. Specify clutch "offset" or "standoff" dimension (Dim. G):
❑ 1.00 ❑ 1.56 ❑ 2.12 ❑ Other _____

Step 6. Select proper hydraulic pump flange (pads) and shaft adapters:

A. ❑ SAE A 2-bolt ❑ SAE B 2- or 4-bolt ❑ SAE C 2- or 4-bolt
❑ SAE D 2- or 4-bolt ❑ Other _____

SAE SHAFT ADAPTERS

SAE SIZE	SPLINED TEETH & PITCH	PLAIN SHAFT W/KEY BORE DIA.	PLAIN SHAFT W/KEY KEY
A	9T-16/32	.625	5/32
BB	15T-16/32	.750	3/16
B	13T-16/32	.875	1/4
C	14T-12/24	1.000	1/5
D	13T-8/16	–	–
Other			

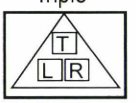
B. Select position:

Single _____

Double

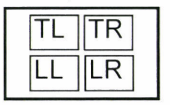
L__ R__

Triple



T__ L__ R__

Quad



TL__ TR__ LL__ LR__

Step 7. Prime Mover Information:

Type: ❑ Electric Motor ❑ Gasoline Engine ❑ Diesel Engine
❑ Other (Specify) _____

Brand Name: _____ Model No. _____

H.P. _____ RPM Max. Torque _____ @ _____ RPM.

Duty Cycle: _____ Hrs./Day _____ Days/Year.

Step 8. Special Options: ❑ Explain _____

Note: Refer to warning, safety and installation pages (1-2) before installing or operating power transmission products

Engine Performance Data

Cummins Inc

Columbus, Indiana 47202-3005
http://www.cummins.com

Industrial

QSB6.7

FR91421

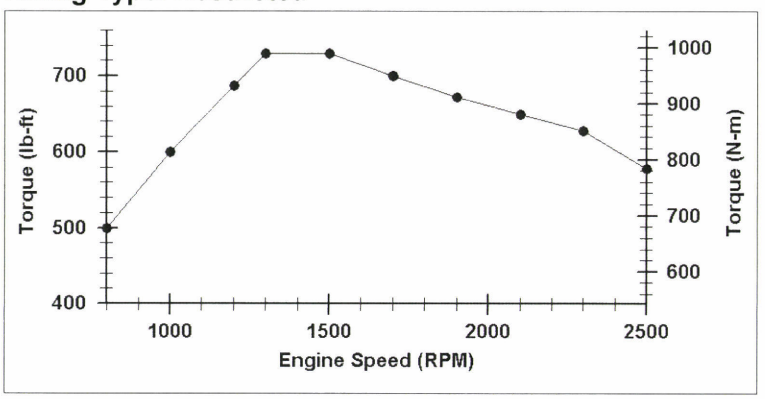
275 BHP (205 kW) @ 2500 RPM
730 lb-ft (990 N-m) @ 1500 RPM

Configuration	CPL Code	Revision
D313001CX03	8611	3-Dec-2004

Compression Ratio:	**17.2:1**	Displacement:	**409 in3 (6.7 L)**
Fuel System:	**Bosch Electronic**	Aspiration:	**Turbocharged and Charge Air Cooled**
Emission Certification:	**U.S. EPA Tier 3, CARB Tier 3, EU Stage III, Pending**		

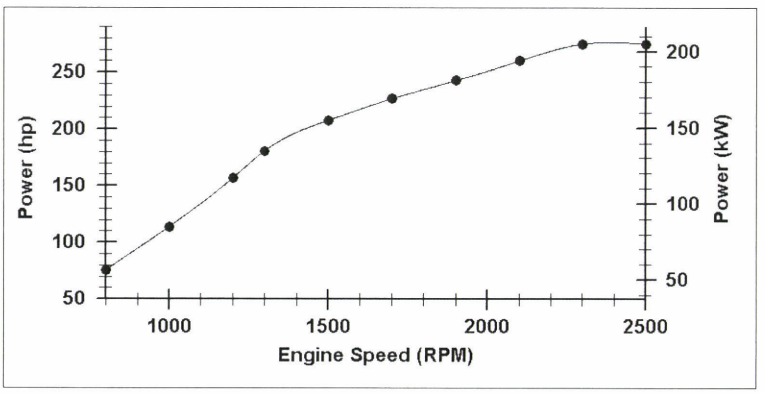
All data is based on the engine operating with fuel system, water pump, and 9.84 in H2O (2.449 kPa) inlet air restriction with 3.94 in (100 mm) inner diameter, and with 1.97 in Hg (7 kPa) exhaust restriction with 2.95 in (75 mm) inner diameter; not included are alternator, fan, optional equipment and driven components. Coolant flows and heat rejection data based on coolants as 50% ethylene glycol/50% water. All data is subject to change without notice.

Rating Type: Restricted



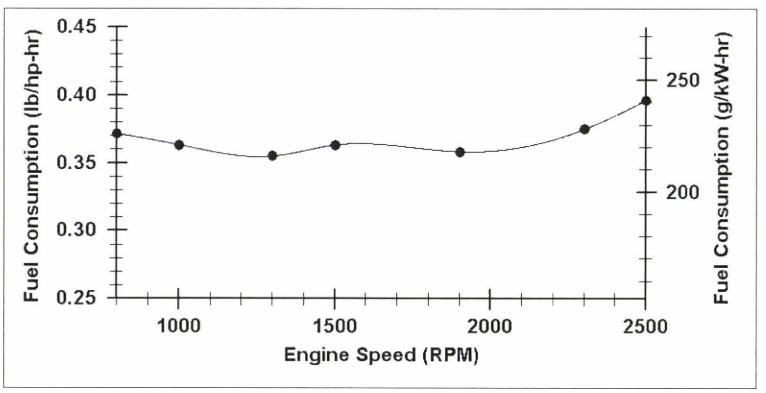
Torque Output

RPM	lb-ft	N-m
800	499	677
1,000	600	813
1,200	687	931
1,300	730	990
1,500	730	990
1,700	700	949
1,900	672	911
2,100	649	880
2,300	628	851
2,500	578	784



Power Output

RPM	hp	kW
800	76	57
1,000	114	85
1,200	157	117
1,300	181	135
1,500	208	155
1,700	227	169
1,900	243	181
2,100	260	194
2,300	275	205
2,500	275	205



Fuel Consumption

RPM	lb/hp-hr	g/kW-hr
800	0.372	226
1,000	0.363	221
1,300	0.355	216
1,500	0.363	221
1,900	0.358	218
2,300	0.375	228
2,500	0.396	241

Curves shown above represent gross engine performance capabilities obtained and corrected in accordance with SAE J1995 conditions of 29.61 in Hg (100 kPa) barometric pressure [300ft (91m) altitude] 77 deg F (25 deg C) inlet air temperature, and 0.30 in Hg (1kPa) water vapor pressure with No. 2 diesel fuel. The engine may be operated up to 7,500 ft (2,286 m) altitude before electronic derate is applied.

STATUS FOR CURVES AND DATA: Preliminary-(estimated data)
TOLERANCE: Within +/- 5 %

CHIEF ENGINEER:
Tim D Britt

Cummins Confidential

Intake Air System

Maximum allowable air temperature rise over ambient at Intake Manifold (Naturally Aspirated Engines) or Turbo Compressor inlet (Turbo-charged Engines): (This parameter impacts emissions, LAT and/or altitude capability)	30.6 delta deg F	17 delta deg C

Charge Air Cooling System

Maximum intake manifold temperature at 25 deg C (77 F) ambient	140 deg F	60 deg C
Maximum allowable pressure drop across charge air cooler and OEM CAC piping (IMPD):	4 in-Hg	14 kPa
Maximum Intake Manifold Temperature Differential (Ambient to IMT) (IMTD):	63 delta deg F	35 delta deg C
Intake manifold temperature for Fan-ON	109 deg F	43 deg C

Exhaust System

Maximum exhaust back pressure:	3.01 in-Hg	10.2 kPa
Recommended exhaust piping size (inner diameter):	2.95 in	75 mm

Lubrication System

Nominal operating oil pressure		
@ minimum low idle	10 psi	69 kPa
@ maximum rated speed	55.1 psi	380 kPa
Minimum engine oil pressure for engine protection devices		
@ minimum low idle	7.5 psi	52 kPa

Fuel System

Fuel cooling requirements (with diesel fuel)		
Maximum heat rejection to return fuel at max. coolant and inlet fuel temperature:	51 BTU/min	0.9 kW
@ fuel return flow rate of:	198 lb/hr	90 kg/hr
@ fuel return temperature prior to cooler:		
Maximum supply fuel flow:	452 lb/hr	205 kg/hr
Maximum return fuel flow:	362 lb/hr	164 kg/hr
Engine fuel compatibility (consult Service Bulletin #3379001 for appropriate use of other fuels)	DF1, DF2	
Maximum fuel inlet pressure:	26 psi	180 kPa

Performance Data

Maximum low idle speed:	1,200 RPM
Minimum low idle speed:	600 RPM
Minimum engine speed for full load sustained operation:	1,700 RPM

	Rated Power		Maximum Power		Torque Peak	
Engine Speed	2,500 RPM		2,300 RPM		1,500 RPM	
Output Power	275 hp	205 kW			209 hp	155 kW
Torque	578 lb-ft	784 N-m	651 lb-ft	883 N-m	730 lb-ft	990 N-m
Friction Horsepower	47 hp	35 kW			19 hp	14 kW
Intake Manifold Pressure	51 in-Hg	171 kPa			49 in-Hg	164 kPa
Turbo Comp. Outlet Pressure	54 in-Hg	182 kPa			50 in-Hg	170 kPa
Turbo Comp. Outlet Temperature	358 deg F	181 deg C			331 deg F	166 deg C
Inlet Air Flow	672 ft3/min	317 L/s			415 ft3/min	196 L/s
Charge Air Flow	51 lb/min	23 kg/min			32 lb/min	14 kg/min
Exhaust Gas Flow	1,676 ft3/min	791 L/s			1,104 ft3/min	521 L/s
Exhaust Gas Temperature	999 deg F	537 deg C			963 deg F	517 deg C
Maximum Fuel Flow to Pump	304 lb/hr	138 kg/hr			225 lb/hr	102 kg/hr
Heat Rejection to Coolant	5,277 BTU/min	92.8 kW			3,731 BTU/min	65.6 kW
Heat Rejection to Fuel	51 BTU/min	0.9 kW			28 BTU/min	0.5 kW
Heat Rejection to Ambient	2,025 BTU/min	35.6 kW			1,376 BTU/min	24.2 kW
Heat Rejection to Exhaust	11,795 BTU/min	207.4 kW			7,234 BTU/min	127.2 kW
**Steady State Smoke	1.2 Bosch				0.3 Bosch	

**When operating Naturally Aspirated engines above SAE J1995 conditions, it should be noted that smoke levels will increase due to combustion inefficiencies associated with a reduction in the air to fuel mixture.

Cranking System (Cold Starting Capability)

Unaided Cold Start:		
Minimum cranking speed:	120 RPM	
Minimum ambient temperature	10.4 deg F	-12 deg C
Cranking torque at minimum unaided cold start temperature:		
Aided Cold Start:		
Minimum ambient temperature with Grid Heater only	-26 deg F	-32 deg C
Minimum ambient temperature with Ether only:	-26 deg F	-32 deg C
Minimum ambient temperature with coolant and lube heater only:	-40 deg F	-40 deg C
Cold starting aids available	Ether, Intake Manifold Heater, Block Heater, Oil Pan Heater	

Noise Emissions

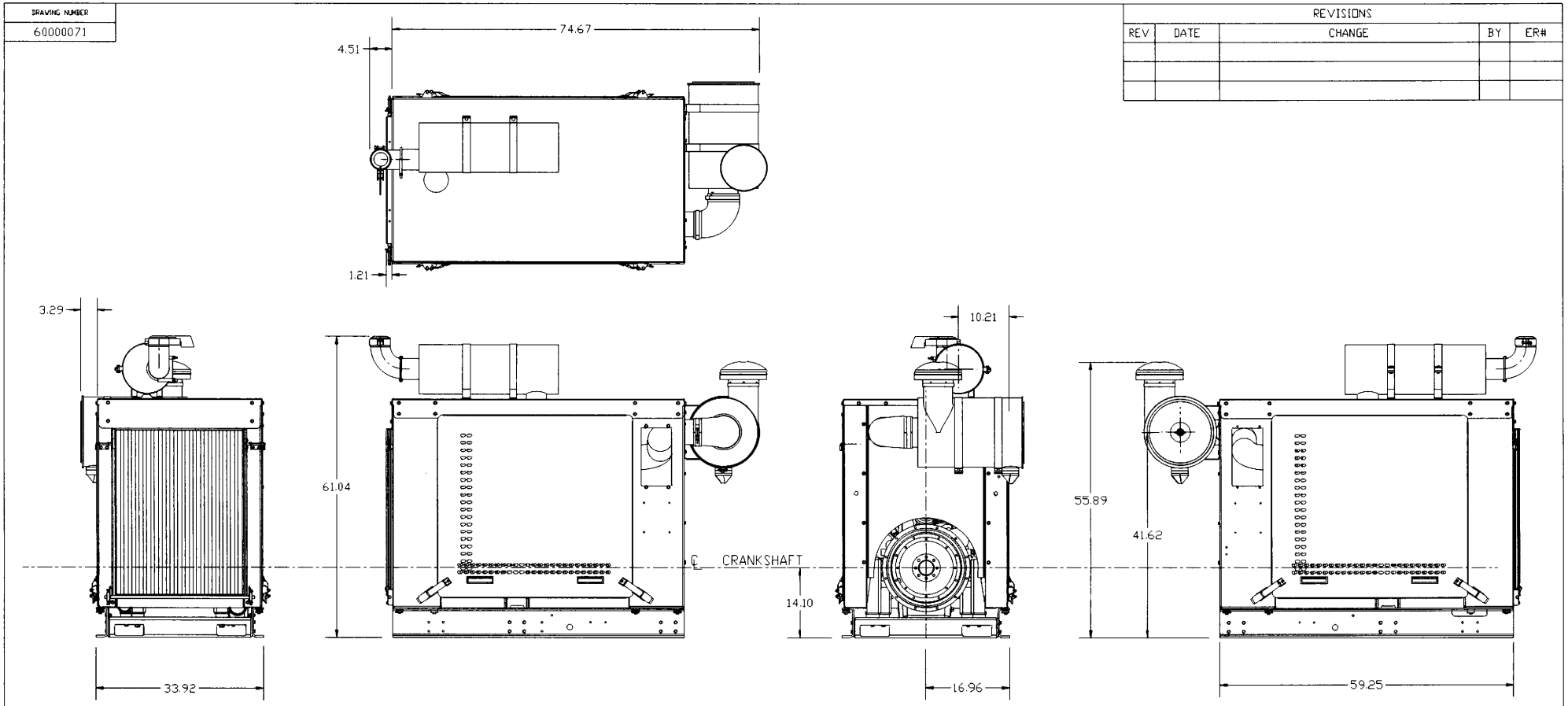
Top	92.5 dBa
Right Side	94.3 dBa
Left Side	93.8 dBa
Front	92.1 dBa
Exhaust noise emissions	114.2 dBa

Estimated Free Field Sound Pressure Level at 3.28ft (1m) and Full-Load Governed Speed
(Excludes Noise from Intake, Exhaust, Cooling System and Driven Components)

End of Report

DRAWING NUMBER
60000071

REVISIONS				
REV	DATE	CHANGE	BY	ER#



SAE #3
M10X 1.5-6H
12 HOLES EQUALLY
SPACED ON A Ø16.87 B.C.

REF. DRAWING STANDARDS: ANSI Y14.5M, ISO R1101 — ALL DIMENSIONS: INCH

CUMMINS POWER PRODUCTS NOVI, MICHIGAN

DRAWN BY DTD	DATE 2/11/00	DRAWING DESCRIPTION	SHEET 1 OF 1
		QSB FULLY ENCLOSED INSTALLATION DIAGRAM	SCALE: NTS
			DRAWING NO. 60000071

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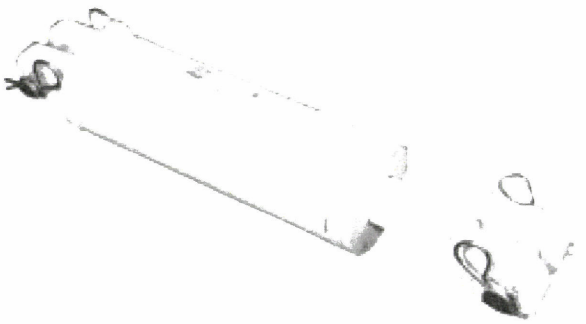
THE SWORD LINE

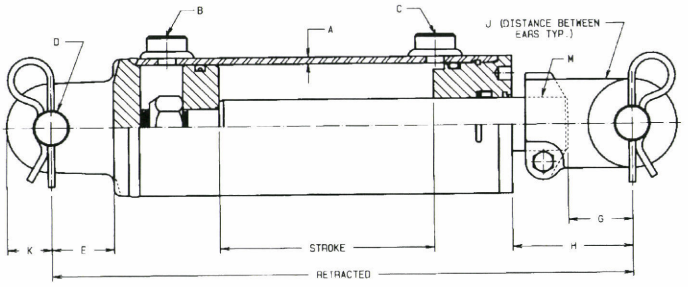
ALL PURPOSE LINE

THE "SWORD" Welded–DA–Heavy Duty–3000 PSI



FEATURES:

- Skived/honed tubing
- Heavy duty welded construction
- Chromed, ground & polished piston rod
- Ductile iron piston, gland & clevis, cast steel base end
- Urethane u-cup & urethane wiper in gland, crown seal on piston
- Square ring gland retainer provides positive lock
- Pins, clips & cotters included
- Standard color is white
- Stroke control may be installed on 8" strokes



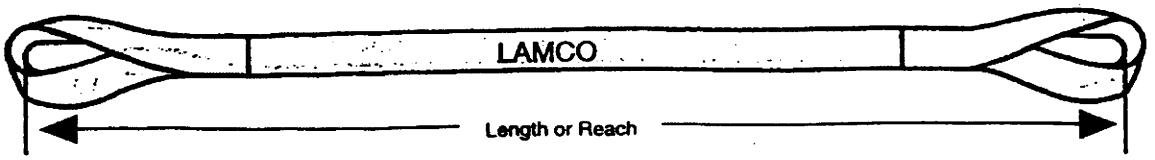
Rods are sized for a maximum safe push load (2:1 safety factor) given in the table. This is based on the pin configuration shown with no center support.

Model No.	Style	Wt.	PSI	Column Load (Lbs.)	Retract	Rod Dia.	A	B NPTF	C NPTF	D	E	G	H	J	K	M
PMC-19408*	1 1/2 x 8	13	3000	Full PSI	20 1/4	3/4	3/16	3/8	3/8	.765	2 5/8	2 5/8	5 1/4	5/8	3/4	–
PMC-19410*	1 1/2 x 10	14	3000	4600 LBS	20 1/4	3/4	3/16	3/8	3/8	.765	2 5/8	2 5/8	3 1/4	5/8	3/4	–
PMC-19412*	1 1/2 x 12	16	3000	3525 LBS	22 1/4	3/4	3/16	3/8	3/8	.765	2 5/8	2 5/8	3 1/4	5/8	3/4	–
PMC-19416*	1 1/2 x 16	20	3000	1525 LBS	31 1/2	3/4	3/16	3/8	3/8	.765	2 5/8	2 5/8	8 1/2	5/8	3/4	–
PMC-42008	2 x 8	19	3000	Full PSI	20 1/4	1 1/8	3/16	1/2	1/2	1.015	1 3/4	1 13/16	5 9/16	1 1/16	1	1 1/8-12
PMC-42010	2 x 10	20	3000	Full PSI	20 1/4	1 1/8	3/16	1/2	1/2	1.015	1 3/4	1 13/16	3 9/16	1 1/16	1	1 1/8-12
PMC-42012	2 x 12	22	3000	Full PSI	22 1/4	1 1/8	3/16	1/2	1/2	1.015	1 3/4	1 13/16	3 9/16	1 1/16	1	1 1/8-12
PMC-42016	2 x 16	25	3000	Full PSI	31 1/2	1 1/8	3/16	1/2	1/2	1.015	1 3/4	1 13/16	8 13/16	1 1/16	1	1 1/8-12
PMC-42020	2 x 20	28	3000	7575 LBS	30 1/4	1 1/8	3/16	1/2	1/2	1.015	1 3/4	1 13/16	3 9/16	1 1/16	1	1 1/8-12
PMC-42024	2 x 24	31	3000	5600 LBS	34 1/4	1 1/8	3/16	1/2	1/2	1.015	1 3/4	1 13/16	3 9/16	1 1/16	1	1 1/8-12
PMC-42508	2 1/2 x 8	21	3000	Full PSI	20 1/4	1 1/4	3/16	1/2	1/2	1.015	1 3/4	1 13/16	5 9/16	1 1/16	1	1 1/8-12
PMC-42510	2 1/2 x 10	22	3000	Full PSI	20 1/4	1 1/4	3/16	1/2	1/2	1.015	1 3/4	1 13/16	3 9/16	1 1/16	1	1 1/8-12
PMC-42512	2 1/2 x 12	23	3000	Full PSI	22 1/4	1 1/4	3/16	1/2	1/2	1.015	1 3/4	1 13/16	3 9/16	1 1/16	1	1 1/8-12
PMC-42516	2 1/2 x 16	27	3000	10800 LBS	31 1/2	1 1/4	3/16	1/2	1/2	1.015	1 3/4	1 13/16	8 13/16	1 1/16	1	1 1/8-12
PMC-42520	2 1/2 x 20	31	3000	11700 LBS	30 1/4	1 1/4	3/16	1/2	1/2	1.015	1 3/4	1 13/16	3 9/16	1 1/16	1	1 1/8-12
PMC-42524	2 1/2 x 24	35	3000	8600 LBS	34 1/4	1 1/4	3/16	1/2	1/2	1.015	1 3/4	1 13/16	3 9/16	1 1/16	1	1 1/8-12
PMC-43008	3 x 8	23	3000	Full PSI	20 1/4	1 3/8	3/16	1/2	1/2	1.015	1 3/4	1 13/16	5 9/16	1 1/16	1 1/8	1 1/8-12
PMC-43010	3 x 10	26	3000	Full PSI	20 1/4	1 3/8	3/16	1/2	1/2	1.015	1 3/4	1 13/16	3 9/16	1 1/16	1 1/8	1 1/8-12
PMC-43012	3 x 12	28	3000	Full PSI	22 1/4	1 3/8	3/16	1/2	1/2	1.015	1 3/4	1 13/16	3 9/16	1 1/16	1 1/8	1 1/8-12
PMC-43016	3 x 16	33	3000	16900 LBS	31 1/2	1 3/8	3/16	1/2	1/2	1.015	1 3/4	1 13/16	8 13/16	1 1/16	1 1/8	1 1/8-12
PMC-43020	3 x 20	39	3000	17300 LBS	30 1/4	1 3/8	3/16	1/2	1/2	1.015	1 3/4	1 13/16	3 9/16	1 1/16	1 1/8	1 1/8-12
PMC-43024	3 x 24	43	3000	12800 LBS	34 1/4	1 3/8	3/16	1/2	1/2	1.015	1 3/4	1 13/16	3 9/16	1 1/16	1 1/8	1 1/8-12
PMC-43508	3 1/2 x 8	29	3000	Full PSI	20 1/4	1 1/2	3/16	1/2	1/2	1.015	1 3/4	1 13/16	5 3/8	1 1/16	1 1/4	1 1/2-12
PMC-43510	3 1/2 x 10	31	3000	Full PSI	20 1/4	1 1/2	3/16	1/2	1/2	1.015	1 3/4	1 13/16	3 3/8	1 1/16	1 1/4	1 1/2-12
PMC-43512	3 1/2 x 12	33	3000	Full PSI	22 1/4	1 1/2	3/16	1/2	1/2	1.015	1 3/4	1 13/16	3 3/8	1 1/16	1 1/4	1 1/2-12
PMC-43516	3 1/2 x 16	38	3000	24200 LBS	31 1/2	1 1/2	3/16	1/2	1/2	1.015	1 3/4	1 13/16	8 3/8	1 1/16	1 1/4	1 1/2-12
PMC-43520	3 1/2 x 20	43	3000	24700 LBS	30 1/4	1 1/2	3/16	1/2	1/2	1.015	1 3/4	1 13/16	3 3/8	1 1/16	1 1/4	1 1/2-12
PMC-43524	3 1/2 x 24	48	3000	18250 LBS	34 1/4	1 1/2	3/16	1/2	1/2	1.015	1 3/4	1 13/16	3 3/8	1 1/16	1 1/4	1 1/2-12
PMC-44008	4 x 8	40	3000	Full PSI	20 1/4	1 3/4	3/16	1/2	1/2	1.015	1 3/4	1 13/16	5 3/8	1 1/8	1 1/4	1 1/2-12
PMC-44010	4 x 10	43	3000	Full PSI	20 1/4	1 3/4	3/16	1/2	1/2	1.015	1 3/4	1 13/16	3 3/8	1 1/8	1 1/4	1 1/2-12
PMC-44012	4 x 12	45	3000	Full PSI	22 1/4	1 3/4	3/16	1/2	1/2	1.015	1 3/4	1 13/16	3 3/8	1 1/8	1 1/4	1 1/2-12
PMC-44016	4 x 16	54	3000	Full PSI	31 1/2	1 3/4	3/16	1/2	1/2	1.015	1 3/4	1 13/16	8 3/8	1 1/8	1 1/4	1 1/2-12
PMC-44020	4 x 20	58	3000	Full PSI	30 1/4	1 3/4	3/16	1/2	1/2	1.015	1 3/4	1 13/16	3 3/8	1 1/8	1 1/4	1 1/2-12
PMC-44024	4 x 24	60	3000	33525 LBS	34 1/4	1 3/4	3/16	1/2	1/2	1.015	1 3/4	1 13/16	3 3/8	1 1/8	1 1/4	1 1/2-12
PMC-44030	4 x 30	65	3000	22900 LBS	40 1/4	1 3/4	3/16	1/2	1/2	1.015	1 3/4	1 13/16	3 3/8	1 1/8	1 1/4	1 1/2-12

* Uses formed clevis & 3/4" pin.

CLASS 98 EYE AND EYE SLINGS

TYPE THREE - FLAT EYE



TYPE FOUR - HALF TWIST EYE

Class 98 slings are made the same as class 75, but are from stronger and slightly thicker webbing. Available in nylon or polyester webbing.

ALL CLASS 98 WEBBING CONTAINS RED WARNING YARNS THAT, WHEN EXPOSED, INDICATE TIME FOR REPLACEMENT.

STOCK NO.	WIDTH	EYE WIDTH	EYE LENGTH	CAPACITY IN LBS.		
				BASKET U	VERTICAL |	CHOKER)
CLASS 98 - ONE PLY						
EE-191	1"	1"	9"	3,100	1,550	1,240
EE-1915	1 1/2"	1 1/2"	9"	4,650	2,325	1,860
EE-192	2"	2"	9"	6,200	3,100	2,480
EE-193	3"	1 1/2"	9"	9,300	4,650	3,720
EE-194	4"	1 1/2"	12"	12,400	6,200	4,960
EE-195	5"	2"	12"	15,400	7,700	6,130
EE-196	6"	2"	12"	18,600	9,300	7,440
EE-198	8"	3"	18"	24,800	12,400	9,920
EE-1910	10"	4"	22"	31,000	15,500	12,400
EE-1912	12"	5"	26"	37,200	18,600	14,880
CLASS 98 - TWO PLY						
EE-291	1"	1"	9"	6,200	3,100	2,480
EE-2915	1 1/2"	1 1/2"	9"	9,300	4,650	3,720
EE-292	2"	2"	9"	12,400	6,200	4,960
EE-293	3"	1 1/2"	12"	18,600	9,300	7,440
EE-294	4"	1 1/2"	12"	22,000	11,000	8,800
EE-295	5"	2"	12"	27,500	13,700	10,900
EE-296	6"	2"	14"	33,000	16,500	13,200
EE-298	8"	3"	18"	44,000	22,000	17,600
EE-2910	10"	4"	22"	55,000	27,500	22,000
EE-2912	12"	5"	26"	66,000	33,000	26,400
CLASS 98 - FOUR PLY						
EE-491	1"	1"	12"	12,400	6,200	4,960
EE-4915	1 1/2"	1 1/2"	12"	18,600	9,300	7,440
EE-492	2"	2"	12"	24,800	12,400	9,920
EE-493	3"	1 1/2"	18"	37,200	18,600	14,880
EE-494	4"	2"	18"	44,000	22,000	17,600
EE-495	5"	2 1/2"	18"	54,900	27,500	21,900
EE-496	6"	3"	20"	66,000	33,000	26,400
EE-498	8"	4"	24"	88,000	44,000	35,200
EE-4910	10"	5"	28"	110,000	55,000	44,000
EE-4912	12"	6"	32"	132,000	66,000	52,800

WEAR PADS AND SLEEVES ARE AVAILABLE. SEE PAGE 17.

Section 4.0
Visual Test Reports

Lift Systems, Inc.

VISUAL TEST REPORT

Work Ticket	Print Number	Description
customer: w/t NAC-ZION 10860	111208 Rev. A	lift link PIN
Type of Material	**Inspection Spec**	**Date and Time of Inspection**
SS Type 630 H925	AWSD1.1	10-05-11 | 12:30 PM

Comments:

On 10-05-11 a load test was conducted on two transporter lift link pins. Part # 111208

Parts were VT and a dimension check was made before test was conducted.

No damage was noted and O.D. dimension was a consistant 4.001 to 4.002.

Pins were placed under a load of 230 TONS for a period of 20 minutes.

Pins were removed From links after load test was completed.

a VT and dimension check was made.

No discontinuities or change to the original dimension check was noted.

Photos were taken of process.

Parts were approved for use.

End.

Inspected by: [signature]

10-13-11
Date

Lift Systems Inc.
Form# QSF080 rev. 000 Date: 10/2011

Lift Systems, Inc.

VISUAL TEST REPORT

Work Ticket	Print Number	Description
11020	111339	Magastor Transfer Cask lift link adapter
Type of Material	**Inspection Spec**	**Date of Inspection**
A36	AWS D1.1	01-09-12

Comments:

On 01-09-12 a load test was conducted on (2) 111339 cask lift links.

Test weight was 65 ton.

Duration of test was 15 min. at complete suspension of weight.

Photograph documentation of test and of links after test was made.

Conclusion:
No noted change to links was noted to links after test had been completed.

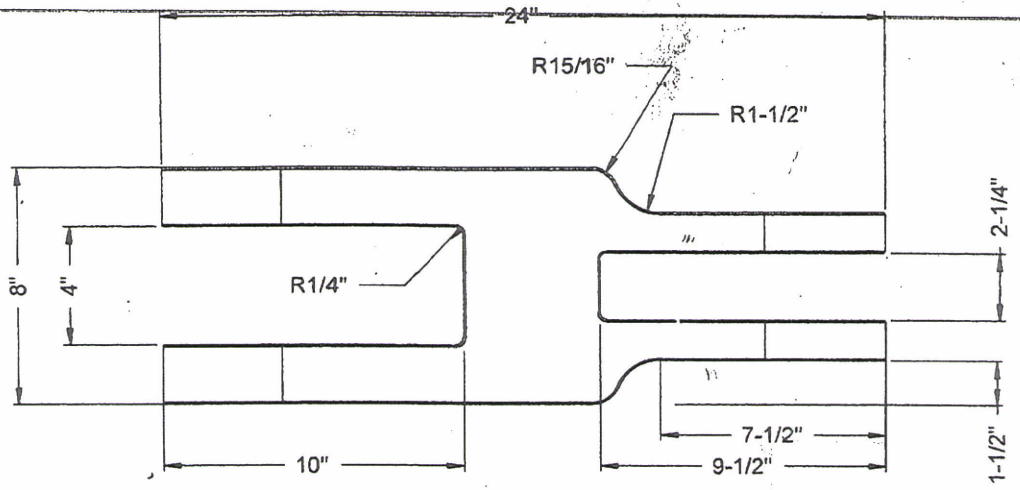
links were approved for use.

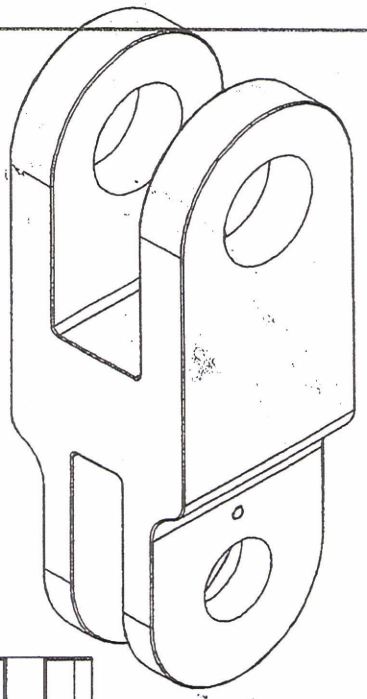
Inspected by: J. Johnston

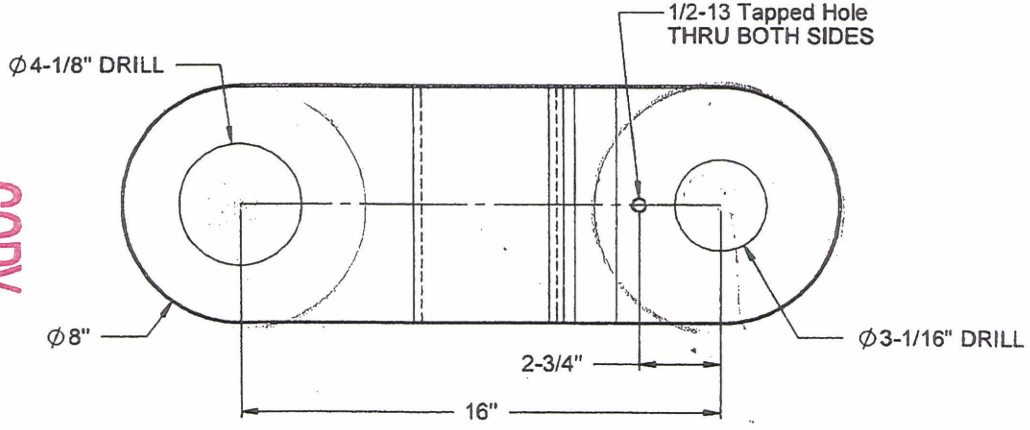
01-11-12
Date

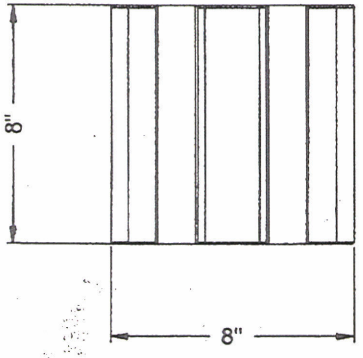
COPY
01-12-12

Lift Systems Inc.
Form# QSF080 rev. 001 Date: 10/2011









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REVISIONS
A-WAS 3-7/8" DRILL NOW 4-1/8"-CRP 2-1-2011

NEXT ASSEMBLY:
ESTIMATED WEIGHT: 203.0 LBS

BREAK CORNERS (except as noted)

TOLERANCES (except as noted)

DECIMAL .XXXX ± .0020" .XXX ± .005" .XX ± .015" .X ± .030"

FRACTIONAL: ±1/16"

ANGULAR: ±1/2°

LIFT SYSTEMS, INC.
216 40TH STREET
MOLINE, ILLINOIS 61265

ISO 9001 REGISTERED

SCALE: 1:6	DRAWN BY: CRP	APPR BY:	
MAT.	ASTM A36		SIZE: A
TITLE	MAGNASTOR TRANSFER CASK LIFT LINK ADAPTER		
DATE 2-1-2011	PART NUMBER	111339	
	REV. A	SHEET 1 OF 1	

99

Lift Systems, Inc.

VISUAL TEST REPORT

Work Ticket	Print Number	Description
10860	111343	Magnastor Transfer Cask link
Type of Material	**Inspection Spec**	**Date of Inspection**
A36	AWSD1.1	01-09-12

Comments:

On 01-09-12 a load test was conducted on (2) 111343 cask lift links.

Test weight was 65 ton.

Duration of test was 15 min. at complete suspension of weight.

Photograph documentation of test and of links after test was made.

Conclusion:

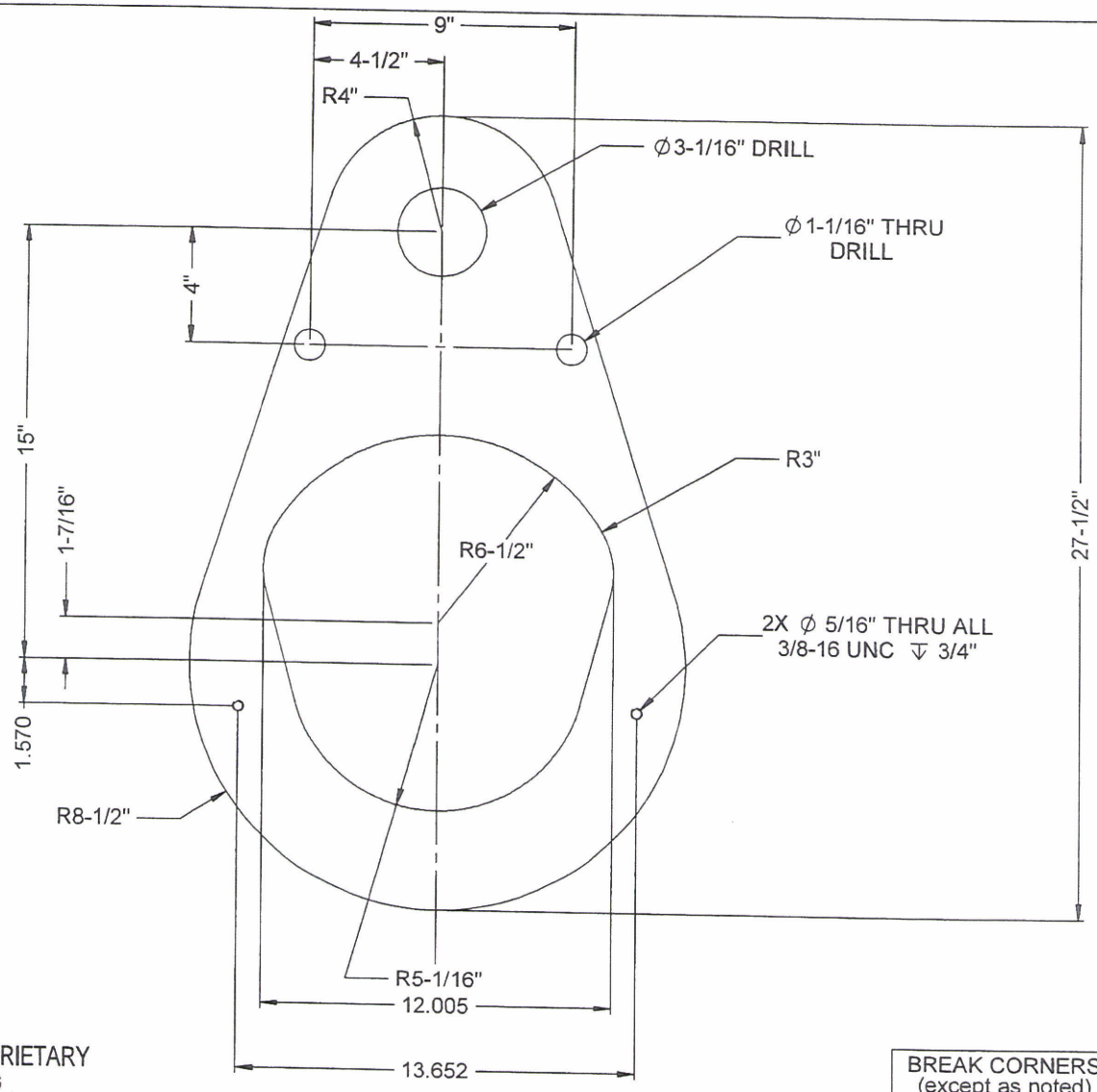
No noted change to links was observed after test had been completed.

links were approved for use.

Inspected by:

01-11-12
Date

COPY 01-12-12



COPY 8/01-12-12

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NEXT ASSEMBLY:
ESTIMATED WEIGHT: 116.2 LBS

REVISIONS

BREAK CORNERS (except as noted)

TOLERANCES (except as noted)

DECIMAL .xxxx ± .0020" .xxx ± .005" .xx ± .015" .x ± .030"

FRACTIONAL: ±1/16"

ANGULAR: ±1/2°

LIFT SYSTEMS, INC.
216 40TH STREET
MOLINE, ILLINOIS 61265

SCALE: 1:6	DRAWN BY: CRP	APPR BY:
MAT. ASTM A36		SIZE: A
TITLE MAGNASTOR TRANSFER CASK LINK		
DATE 5-5-2003	PART NUMBER 111343	
	REV.	SHEET 1 OF 1

101

Section 5.0
Factory Functional and Dynamic Test, Load Test

NOT QUALITY RELATED

Vertical Cask Crawler Functional Test Checklist

		Inspector
Verify Following Dimensions	**DIMENSIONS** Length 292" RS Outer width 220" RS Inner width 132" RS Track width 24½" RS Track length 254" RS Upper lift link height above grade Outer lift link width with side shift cylinders retracted RS Outer lift link width with side shift cylinders extended RS	RS 9/23/11 Randy Steck
	LOAD TEST 125% of 180 ton rated load = 225 tons (19 BLOCKS)	
Lift and Hold Test	Raise and hold test weight for 10 minutes and lower Verify: No significant leakage at piston seals RS No significant leakage at lift cylinder hoses RS Cylinder pressure reads as expected (~~2,400~~-2,500 psi) 2500 RS Cylinders operate in unison	Randy Steck 9/23/11
Post load Test Inspection of Primary Lift Welds	Disconnect lift links and visually inspect primary load bearing members. Verify members are free of: Damage Cracking Deformation	
Raise test weight	Raise to height of 18 inches 13" RS	
	DRIVING TEST 180 ton load (16 BLOCKS = 188 TONS)	
Drive around test area with 180 ton test weight	Test the following: Drive forward RS Reverse RS Forward left turn RS Forward right turn RS Reverse turns RS Test Dead man controls (~~seat~~, joystick, brake switch) NA CRP 9/28/11 Test instrumentation throughout ~~Oil switch kill feature (40 psi to release)~~ NA CRP 9/28/11 Brakes forward and reverse Measure speed FORWARD 27 SEC. REVERSE 30 SEC. 25 FEET RIGHT COUNTER ROTATE LEFT COUNTER ROTATE RS	9/23/11
Inspection	Verify None of the following: Leaking hydraulic fluid RS Cracked welds in main frame RS Oil temperature RS Damaged tracks RS	9/23/11

CT208040 Functional test

Sheet 1 of 2

103

Vertical Cask Crawler Functional Test Checklist

	DIMENSIONS	Inspector
Verify Following Dimensions	Length Outer width Inner width Track width Track length Upper lift link height above grade Outer lift link width with side shift cylinders retracted Outer lift link width with side shift cylinders extended	See Previous Test Sheet
	LOAD TEST 125% of 180 ton rated load UP OK	
Lift and Hold Test	Raise and hold test weight for 10 minutes and lower Verify: 9:22 9:32 60" No significant leakage at piston seals NOV No significant leakage at lift cylinder hoses None Cylinder pressure reads as expected (2,400-2,500 psi) 12:25 12:35 57" Cylinders operate in unison Yes 2250psi	CAP 9/28/11
Post load Test Inspection of Primary Lift Welds	Disconnect lift links and visually inspect primary load bearing members. Verify members are free of: Damage Cracking Deformation	
Raise test weight	Raise to height of ~~16~~ 13" inches	CAP 9/28/11
	DRIVING TEST 180 ton load	
Drive around test area with 180 ton test weight	Test the following: RS Drive forward ✓ R2 Reverse ✓ RS Forward left turn ✓ RS Forward right turn ✓ RS Reverse turns ✓ RS Test Dead man controls (seat, joystick, brake switch) ✓ RS Test instrumentation throughout ✓ ~~Oil switch kill feature (40 psi to release)~~ R2 Brakes forward and reverse ✓ Measure speed over 25ft 27sec forward 27 Rev. 1900 PSI Lift until pressure	90° Right 90° Left CAP 9/28/11
Inspection	Verify None of the following: Leaking hydraulic fluid None Observed Cracked welds in main frame Oil temperature Damaged tracks	CAP 9/28/11

CT208122 Functional test for NAC only Witnessed by: 9/28/11

104

Cask Transporters Inspection Sheet

These sheets will be on each piece of equipment as it is built and will be filled out as each section is completed.

W.O. #12366 MODEL # CT201071L SERIAL# CTC180005

Sheet 1 of 3

	Inspection Prior To Shipment Completed by	Verified by	On-site Inspection Verified by
1) Tanks have been air tested.			
2) Tanks have been cleaned.			
3) Fittings and hoses not leaking.			
4) Drive motors rotate properly.			
5) Lay of hoses (no twist, sharp bends, or kinks).			
6) Counter balance valves set.			
a) Hoist 2000 PSI 4500 PSI			
b) All bearing and wear surfaces have grease.			
7) Cylinders have proper clearance and alignment.			
8) Cylinders filled and bled.			
9) Gearboxes filled with gear lube.			
10) Brakes filled with oil.			
11) Engine has proper oil and coolant and at proper level.			
12) Pressures set.			
a) Hoist 2500 PSI			
b) Drives RT 5000 PSI LT 5000 PSI			
c) Charge PSI. RT 325 PSI LT 325 PSI			
13) All serial numbers recorded.			
a) Hoist cylinders S/N 03111 S/N 03111			
b) Super Flex S/N N/A			
c) Joystick S/N 11159-1			
d) Engine M/N QSB6.7L S/N 73243508 TOP RPM 2500			
e) Drive Motor S/N 3806236 S/N 3806231 RS/N N/A			
d) Drive Pumps S/N 3806192 S/N N/A 3806191			
14) All shims are in and tight.			

Unit is complete and ready for test

Assembly Raymond Lugo 9-28-11 Date

Quality 09-29-11 Date

Cask Transporters Inspection Sheet

These sheets will be on each piece of equipment as it is built and will be filled out as each section is completed.

W.O. # 10860 MODEL # CT201077 SERIAL# CTC180005

Sheet 2 of 3

	Inspection Prior To Shipment		On-site Inspection
	Completed by	Verified by	Verified by
15)			
16) All grease points greased.			
17) Decals in proper location.	DB	DB	
18) Serial number is stamped on unit.	DB	DB	
19) Unit has been function tested.	RS		
20) Overall appearance. (No chips in paint, runs. sags, no footprints, excess grease or metal shavings)	DB	DB	
21) No sharp edges.	DB	DB	
22) Edging put on to protect hoses.	RS		
23) Lifting units go up even.			
24) Unit travels straight in both directions.	RS		
25) Wedge lock assemblies installed			
a) Connector link	N/A	NA	
b) Wedge pivot arm	N/A	NA	
c) Wedge manual lockouts with pins	N/A	NA	
d) Proximity switches installed		RS	
e) Wedge cylinder / spring / collar		RS	
f) Wedge solenoid assembly	N/A	NA	
g) Pressure transducer in cylinder for solenoid	RS		
26) Fire extinguisher installed	DB	DB	
27) Pendant brake installed	N/A	N/A	
28) Strap cylinder installed	RS		
29) Superflex Optimizer in electrical cabinet	N/A	N/A	
30) Console boxed in with plywood with cover inside			
31) Chassis bolts for center section boxed			
32) Lift unit bolts boxed/installed			

Cask Transporters Inspection Sheet

These sheets will be on each piece of equipment as it is built and will be filled out as each section is completed.

W.O. # 10860 MODEL # CT201072 SERIAL# CTC180005

Sheet 3 of 3

	Inspection Prior To Shipment		On-site Inspection
	Completed by	Verified by	Verified by
33) Header beam bolts boxed/installed	[illegible]	[illegible]	
34) Straps, Fittings and pins boxed	[illegible]	[illegible]	
35) All hoses and electrical cords secured for shipping	[illegible]	[illegible]	
36) All hoses capped or plugged for shipping	[illegible]	[illegible]	
37) Cask bumpers			
a) Long bumpers	DB	DB [illegible]	
b) Short bumpers	DB	DB [illegible]	
38) Chassis ladder	DB	DB [illegible]	
39) Unit is fully tested	[illegible]	[illegible]	
40) Unit is ready for final inspection.	[illegible]	[illegible]	

Upon completion the inspection sheets are to be filed with the machine file.

Additional notes:

MDL2 SN# 127230033, XA2 SN# 118040127, XS2 SN# 117040016

Section 6.0
Winch Test Report

NOT QUALITY RELATED

Vertical Cask Crawler Functional Test Checklist

		Inspector / Customer witness
	FUNCTIONAL WINCH TEST CONNECT WINCH TO A FIXED WEIGHT OR LARGE FORK TRUCK	
Function test of winch	Test the following: Forward, winch cable in. Reverse, winch cable out	3-12-12 Randy Stark
	Single line pull test	
	Payout cable to bare drum with 5 wraps minimum remaining. Attach cable hook to a heavy moveable object Winch rope in with one part of line. Record load cell reading 4955 lbs	3-12-12 Randy Stark
	Two part line pull test	
	Payout cable to bare drum with 5 wraps minimum remaining. Attach cable hook to a heavy moveable object using pully block Winch rope in with two parts of line. Record load cell reading - 3900-4200 lbs	CAP 3-7-2012 Randy Stark
Inspection	Verify None of the following: Cable is not damaged - None observed Winch brackets not damaged - None Winch brackets not damaged - None Winch operates proper direction - Yes	3-12-12 Randy Stark

Comments

Section 7.0
Post Factory Test Punchlist

NOT QUALITY RELATED

updated 10/26/2011

CRP updated 1-12-2012 CRP

Zion Solutions Vertical Cask Transporter
Lift Systems, Inc.
Post Factory Test Completion Punch List
9/30/11

updated 3.27.12 CRP

1. Remove, blast, prime and top coat lift links. When all testing is complete Completed CRP 3.27.12
2. Wrap wires and cables on towers. Rowdy Stock
3. Add 4 more lights and power outlets to transporter. Verify adequacy of lighting for night operations. Rowdy Stock
4. Check handrail height & kick plate OSHA (or other applicable regulatory body) requirements OSHA 1926.502 SENT 10-19-2011
5. Add adjust group for auto rotation to reduce pump flow to prevent stalling of engine. Done CRP
6. Check torque on track bolts to side frame. Rowdy Stock
7. Clean unit, mist coat with epoxy, apply non-skid on deck and finish paint. When prepping to ship Completed CRP 3.27.2012
8. Spare parts list. Sue Hansen Sent. CRP
9. Send preliminary operators manual. Sent Duke Catawba but Diablo would be closer match. Duke one was Sent. CRP
10. Assemble bumpers into chassis. Rowdy Stock
11. Add boots to toggles for lights. Rowdy Stock
12. Complete operators manual. Rick 60% Complete.
13. Review CARL program for additions of adjust groups and text corrections.
14. Provide ZS site assembly support requirements. (Cranes, forklift, labor, etc)
15. Provide track tension tool. Rowdy Stock
16. Install and Test Winch (after NAC PO change) Completed 3.12.2012 CRP
17. Complete calibration of CARL System. Demonstrate 24" max cask height limit during Zion site test. When re-assembled at site Program Done but not Tested. CRP Done CRP
    - On display, "Left-Right" direction" was incorrectly programmed to read "Left-Left" Done CRP
    - When turning 360 degrees under 100% load, the machine stalled twice Done, Not Tested under Load. CRP
18. Bundle and tie up electrical and hydraulic lines as needed to prevent damage during operation. Rowdy Stock
19. Install weather protection for electrical lines and wiring harnesses at all panels/junction boxes. as necessary. Rowdy Stock
20. Install grating and handrail in front of operator. Rowdy Stock
21. Install operator control console panel and protective weather cover over console and chair. Rowdy Stock needs to be Redone
22. Test links and pins for VCC and MTC not used in Factory test on 9/28/11. A separate load test of actual pins is required. Jim Freyman 65 ton 1-9-12

23. Verify heaters work. Randy Stod
24. Re- assemble beam and links onto transporter for show and tell. Randy Stod

Section 8.0
Cask Transporter Inspection Sheet
(Post Delivery to Zion)

Cask Transporters Inspection Sheet

These sheets will be on each piece of equipment as it is built and will be filled out as each section is completed.

W.O. #[illegible] MODEL # CT2.0 1 0 7 L SERIAL # CTC.1 [illegible]

Sheet 1 of 3

	Completed by	Inspection Prior To Shipment Verified by	On-site Inspection Verified by
1) Tanks have been air tested.			
2) Tanks have been cleaned.			
3) Fittings and hoses not leaking.			
4) Drive motors rotate properly.			
5) Lay of hoses (no twist, sharp bends, or kinks).			
6) Counter balance valves set.			
a) Hoist [illegible] PSI [illegible] PSI			
b) All bearing and wear surfaces have grease.			
7) Cylinders have proper clearance and alignment.			
8) Cylinders filled and bled.			
9) Gearboxes filled with gear lube.			
10) Brakes filled with oil.			
11) Engine has proper oil and coolant and at proper level.			
12) Pressures set.			
a) Hoist 2500 PSI			
b) Drives RT 5000 PSI LT 5000 PSI			
c) Charge PSI. RT [illegible] PSI LT [illegible] PSI			
13) All serial numbers recorded. 5397 [illegible] 25397			
a) Hoist cylinders S/N 03111 S/N 03115-1			
b) Super Flex S/N N/A			
c) Joystick S/N LL159-1			
d) Engine M/N QSB6.7L S/N [illegible] TOP RPM 2500			
e) Drive Motor S/N 3180623C S/N 3180623 RS/N N/A			
d) Drive Pumps S/N [illegible] S/N N03 806-191			
14) All shims are in and tight.			

Unit is complete and ready for test

Assembly [signature] Date 9-28-11

Quality [signature] Date 09-29-11

Cask Transporters Inspection Sheet

These sheets will be on each piece of equipment as it is built and will be filled out as each section is completed.

W.O. # 10860 MODEL # CT201077 SERIAL # CTC180005

Sheet 2 of 3

	Inspection Prior To Shipment		On-site Inspection
	Completed by	Verified by	Verified by
15)			
16) All grease points greased.			
17) Decals in proper location.	DB	DB	
18) Serial number is stamped on unit.	DB	DB	
19) Unit has been function tested.			
20) Overall appearance. (No chips in paint, runs. sags, no footprints, excess grease or metal shavings)	DB	DB	
21) No sharp edges.	DB	DB	
22) Edging put on to protect hoses.			
23) Lifting units go up even.			
24) Unit travels straight in both directions.			
25) Wedge lock assemblies installed			
a) Connector link	N/A	NA	
b) Wedge pivot arm	N/A	NA	
c) Wedge manual lockouts with pins	N/A	NA	
d) Proximity switches installed			
e) Wedge cylinder / spring / collar			
f) Wedge solenoid assembly	N/A	NA	
g) Pressure transducer in cylinder for solenoid			
26) Fire extinguisher installed	DB	DB	
27) Pendant brake installed	N/A	N/A	
28) Strap cylinder installed			
29) Superflex Optimizer in electrical cabinet	N/A	N/A	
30) Console boxed in with plywood with cover inside			
31) Chassis bolts for center section boxed			
32) Lift unit bolts boxed/installed			

Cask Transporters Inspection Sheet

These sheets will be on each piece of equipment as it is built and will be filled out as each section is completed.

W.O. # 10860 MODEL # CT201072 SERIAL # CTC180005

Sheet 3 of 3

	Inspection Prior To Shipment		On-site Inspection
	Completed by	Verified by	Verified by
33) Header beam bolts boxed/installed			
34) Straps, Fittings and pins boxed			
35) All hoses and electrical cords secured for shipping			
36) All hoses capped or plugged for shipping			
37) Cask bumpers			
a) Long bumpers	DB	DB	
b) Short bumpers	DB	DB	
38) Chassis ladder	DB	DB	
39) Unit is fully tested			
40) Unit is ready for final inspection.			

Upon completion the inspection sheets are to be filed with the machine file.

Additional notes:

MDL2 SN# 1272 30033, XA2 SN# 1180 40127, X52 SN# 1170 40016

Section 9.0
On-site Zion Post-Assembly Inspection and Functional Test Report

Dan's

Zion Solutions Vertical Cask Transporter

On-site Post Assembly Inspection and Functional Test

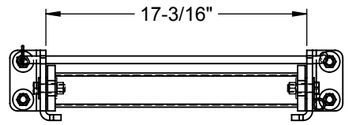
To be completed for Inspection Sheet Items #19 and #39 at Zion

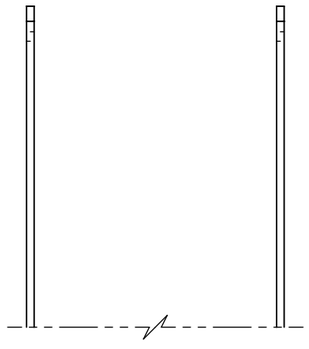
1.	Verify correct fluid levels	4/5/12
2.	Start engine and bring to operating temperature	4/5/12
3.	Verify no hydraulic, fuel, oil, or exhaust leaks	4/5/12
4.	Verify all instrumentation is working properly	4/5/12
5.	Drive forward	4/5/12
6.	**Confirm capability to reach design speed**	4/5/12
7.	Drive reverse	4/6/12
8.	Forward left turn	4/6/12
9.	Forward right turn	4/5/12
10.	Reverse turns	4/5/12
11.	Test brakes forward and reverse	4/5/12
12.	Raise and lower booms	4/5/12
13.	Verify wedges engage and disengage	4/5/12
14.	Test side shift in both directions	4/5/12
15.	Check winch operations	4/6/12
16.	Test dead man controls (seat, joystick, and brake switch)	4/5/12
17.	**Test oil switch kill feature (40 psi to release)**	N/A 4/5/12
18.	Test Emergency Stop	4/5/12
19.	Test CARL controls	4/5/12
20.	Test Radio Remote Controls	4/5/12
21.	Set CARL max height control -- to be completed under load.	
22.	Test lights are operational	4/5/12

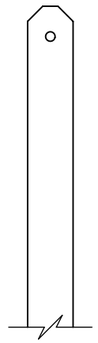
4/6/12

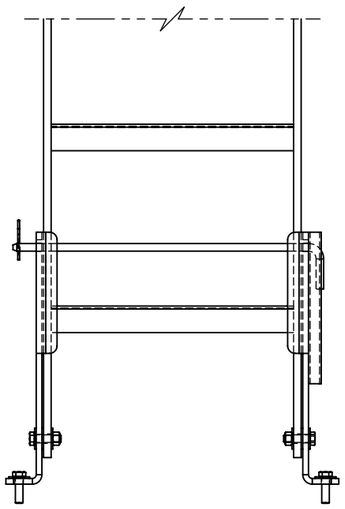
Completed By Date

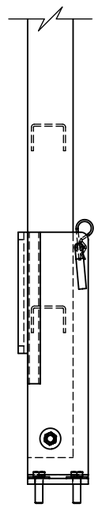
Section 10.0
VCT Ladder

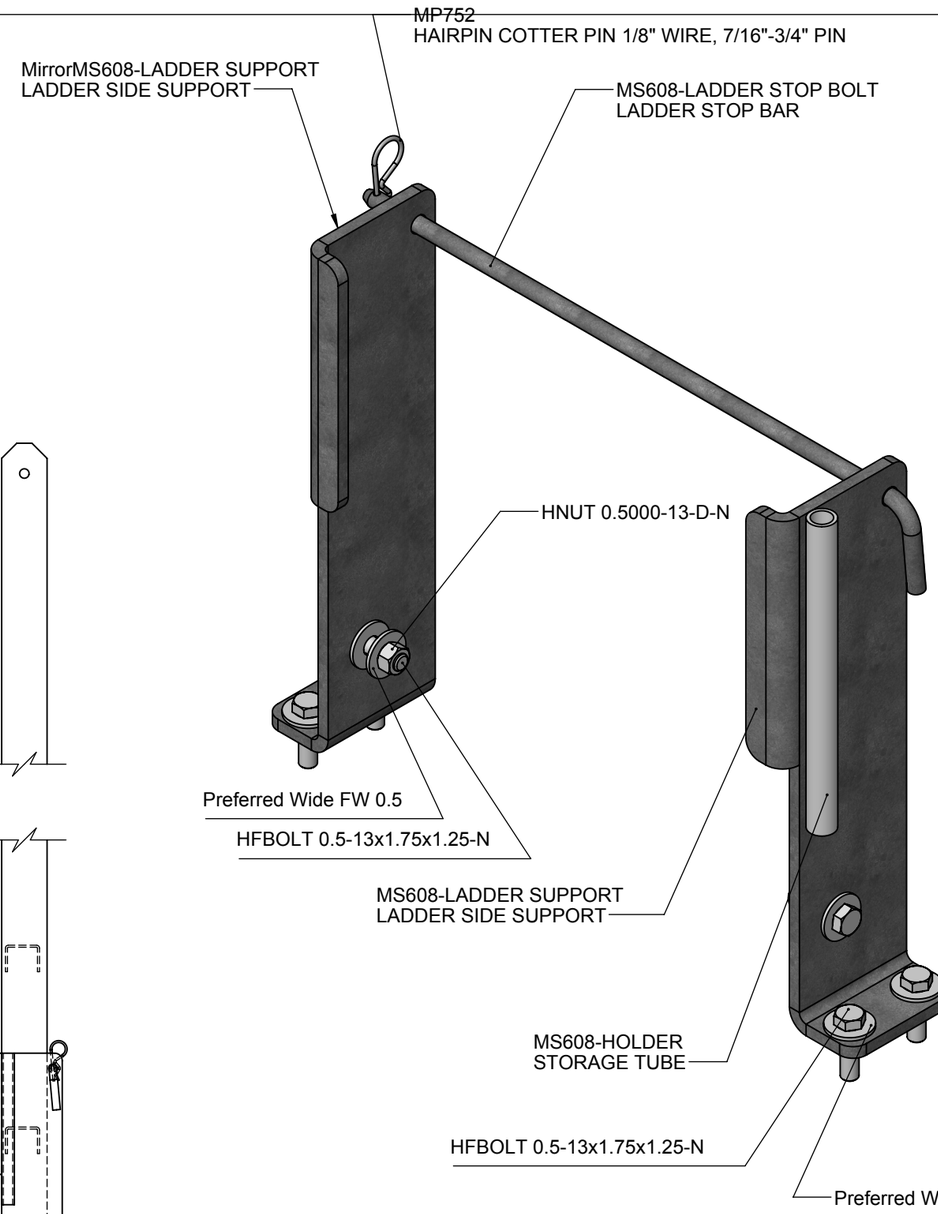


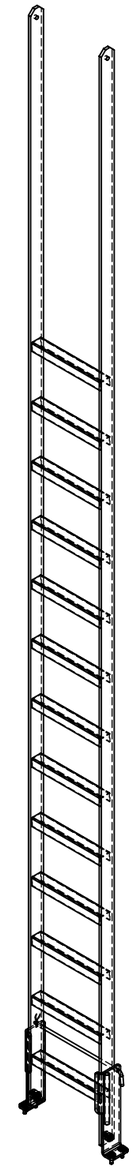












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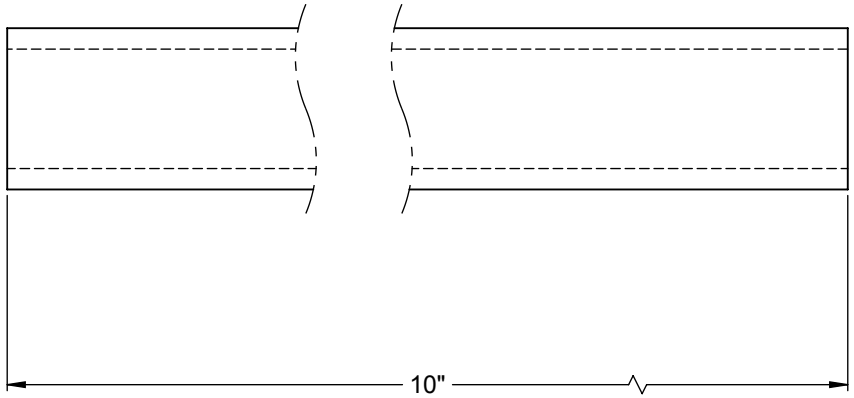
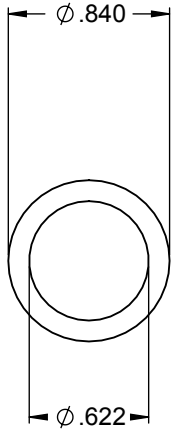
NEXT ASSEMBLY:
ESTIMATED WEIGHT: 20.0 LBS

REVISIONS

TOLERANCES (EXCEPT AS NOTED)	LIFT SYSTEMS, INC. 1505 7TH STREET EAST MOLINE, ILLINOIS 61244		
DECIMAL .xxxx ± .0020" .xxx ± .005" .xx ± .015" .x ± .030"	SCALE: 1:10	DRAWN BY: CRP	APPR BY:
	MAT.		SIZE: B
FRACTIONAL ± 1/16"	TITLE	VCT LADDER	
ANGULAR ± 1/2°	DATE 11-9-2015	PART NUMBER	MS608
		REV.	SHEET 1 OF 1





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NEXT ASSEMBLY:
ESTIMATED WEIGHT: 0.7 LBS

REVISIONS

BREAK CORNERS (except as noted)

TOLERANCES (except as noted)

DECIMAL .xxxx ± .0020"
.xxx ± .005"
.xx ± .015"
.x ± .030"

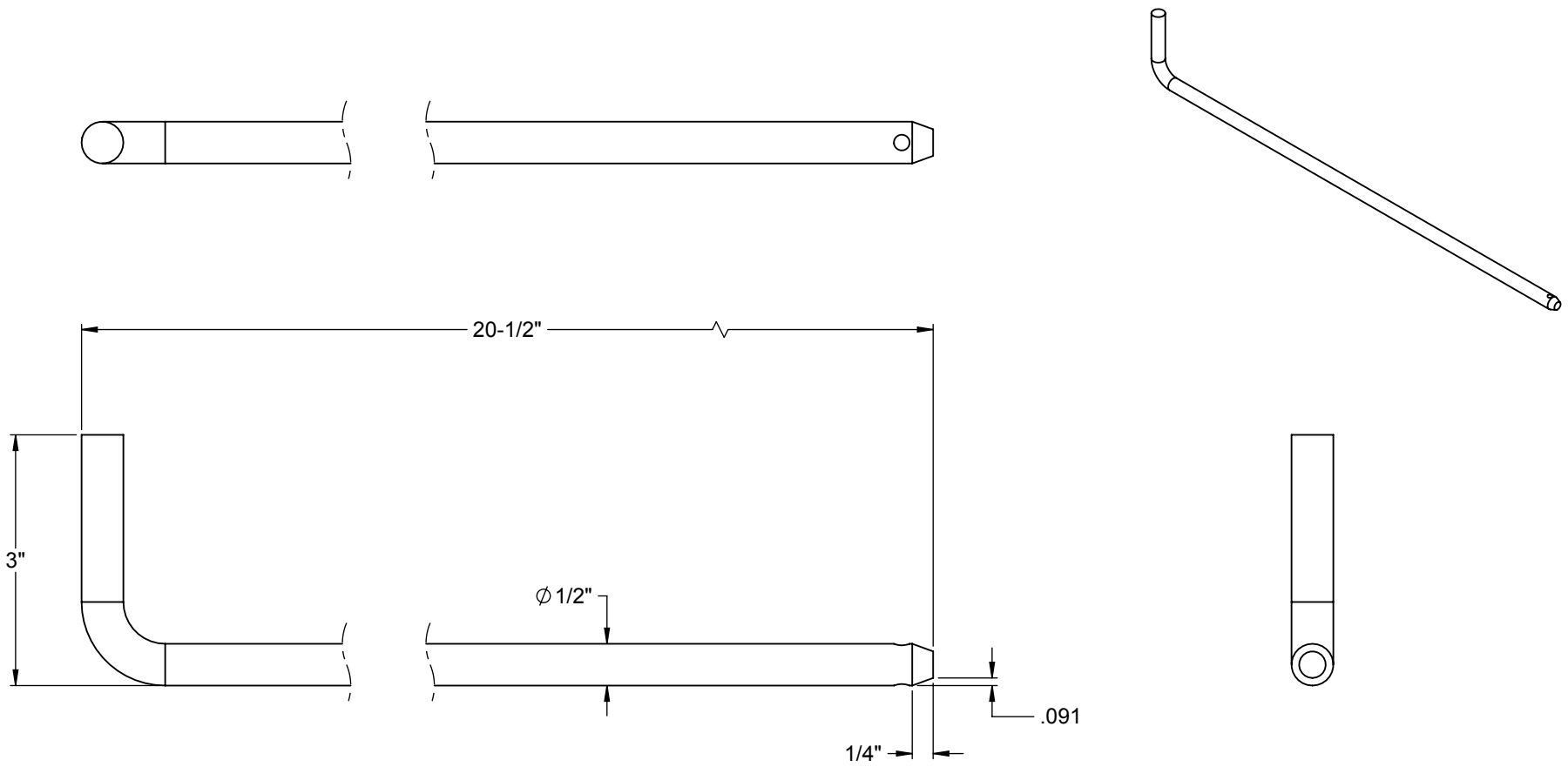
FRACTIONAL: ±1/16"

ANGULAR: ±1/2º

LIFT SYSTEMS, INC.
1505 7TH STREET
EAST MOLINE, ILLINOIS 61244

SCALE: 1:1	DRAWN BY: CRP	APPR BY:	
MAT.	Plain Carbon Steel 1/2" SCH 40 BP		SIZE: A
TITLE	STORAGE TUBE		
DATE 11-9-2015	PART NUMBER	MS608-HOLDER	
	REV.	SHEET 1 OF 1	

11/9/2015 4:51 PM



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LIFT SYSTEMS
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REVISIONS

NEXT ASSEMBLY:
ESTIMATED WEIGHT: 1.3 LBS

BREAK CORNERS (except as noted)

TOLERANCES (except as noted)

DECIMAL .xxxx ± .0020" .xxx ± .005" .xx ± .015" .x ± .030"

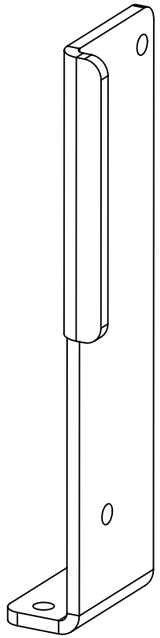
FRACTIONAL: ±1/16"

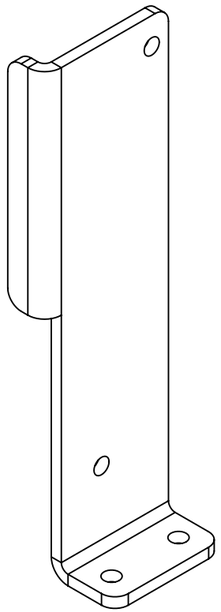
ANGULAR: ±1/2°

LIFT SYSTEMS, INC.
1505 7TH STREET
EAST MOLINE, ILLINOIS 61244

SCALE: 1:2	DRAWN BY: CRP	APPR BY:	
MAT. ASTM A36			SIZE: A
TITLE LADDER STOP BAR			
DATE 11-9-2015	PART MS608-LADDER STOP BOLT		
	REV.	SHEET 1 OF 1	

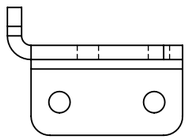
11/9/2015 4:27 PM

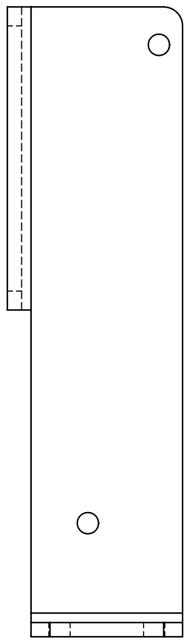


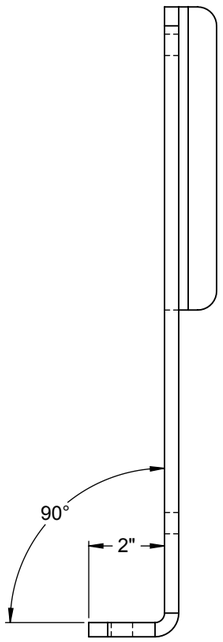


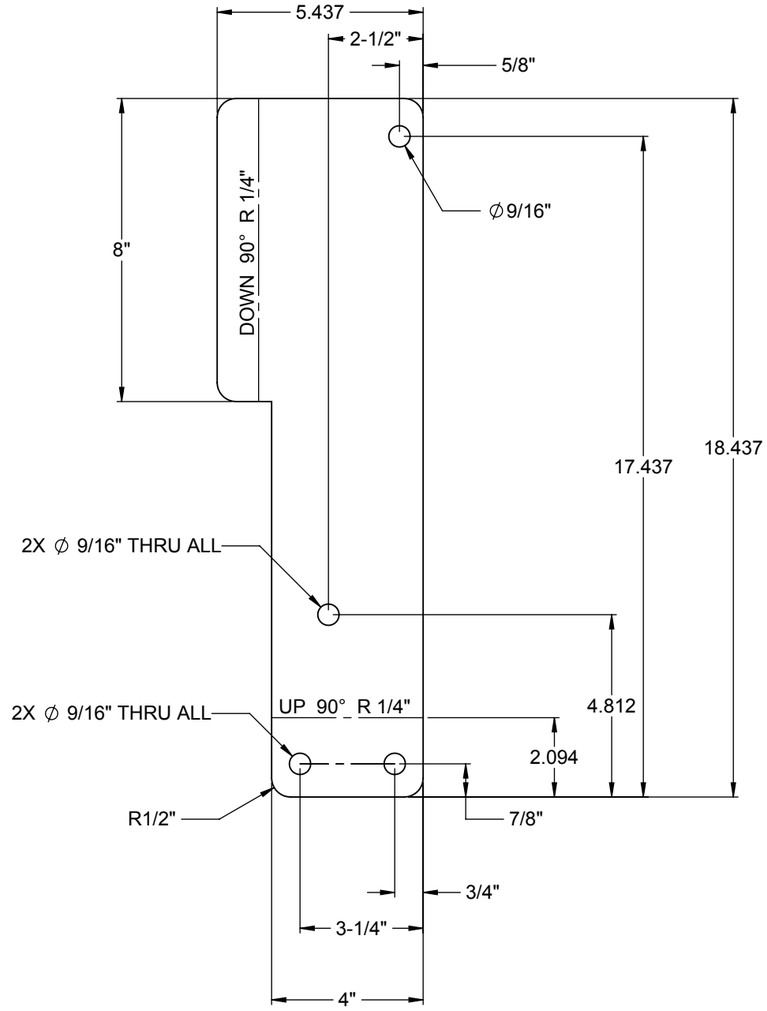
NOTE

MAKE (1) RIGHT HAND AND (1) LEFT HAND.









COMPANY PROPRIETARY

LIFT SYSTEMS
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NEXT ASSEMBLY:
ESTIMATED WEIGHT: 8.9 LBS

REVISIONS

TOLERANCES (EXCEPT AS NOTED)	LIFT SYSTEMS, INC. 1505 7TH STREET EAST MOLINE, ILLINOIS 61244		
DECIMAL .xxxx ± .0020" .xxx ± .005" .xx ± .015" .x ± .030"	SCALE: 1:4	DRAWN BY: CRP	APPR BY:
	MAT. ASTM A36		SIZE: B
FRACTIONAL ± 1/16"	TITLE	LADDER SIDE SUPPORT	
ANGULAR ± 1/2°	DATE 11-9-2015	PART	MS608-LADDER SUPPORT
		REV.	SHEET 1 OF 1

Section 11.0
On-site Kewaunee Inspections

Dominion

WORK ORDER

KW100997704

FOR INFORMATION ONLY

PARENT WO:		UNIT- 01	WO REV LEVEL: 0
PLANNER:	DAVID W DAGNEAU		CONTROLLED COPY PRINT: 1
LEAD CRAFT:	MECH		

NAC ISFSI | **NON SAFETY RELATED**

WORK DESCRIPTION: Support for NAC ISFSI campaign.

AS LEFT / WORK PERFORMED

ACTUAL START DATE/TIME: 02/27/16 06:00 AM ~~9/31/2015 12:42:30 PM~~ MKH 2-27-16 | NAME: MARK K. HIRST / BRYAN DIETZ

LUBRICATED VCT LIFT TOWERS

TORQUE CHECK OF LIFT TOWER TO LIFT BEAM BOLTING ON VCT TO 385 FT LBS

TOOLS: • JLG ARTICULATING BOOM LIFT
- 0 TO 400 FT LB TORQUE WRENCH, 3/4" DRIVE
- 1 1/2" 6 PT SOCKET 3/4" DRIVE
- 1 1/2" CROWS FOOT
- 1/2" TO 3/4" DRIVE ADAPTER
- DUPONT NUTO STICK DRY FILM LUBRICANT

PPE: FALL PROTECTION & HARNESS AND LANYARD

NOTE: PERFORMED APPENDIX C OF WESTINGHOUSE PROCEDURE, MRS-SSP-3230, VERTICAL CASK TRANSPORTER (VCT) OPERATION AT KEWAUNEE UNIT 1. VCT PRE-USE INSPECTIONS + MAINTENANCE CHECKLIST. ALL RESULTS SAT.

POWER UNIT HOURS: 982.2 START
983.3 STOP

02/29/16: SMALL LEAK ON POWR UNIT GEAR PUMP, MAYBE RESIDUAL FROM PREVIOUS TIGHTENING ON 2/18/16. WILL MONITOR AND DETERMINE IF FURTHER ACTION IS NEEDED. MKH 2/29/16

ACTUAL COMPLETION DATE/TIME:	02/27/16 11:00 AM	NAME:	MARK K HIRST
REMOVED DEF TAG: N/A		TAG NUMBER: N/A	
SUBMITTED CR: N/A		CR NUMBER: N/A	

CONTINUED ON 0 ADDITIONAL SHEETS

APPENDIX C VCT PRE-USE INSPECTIONS & MAINTENANCE CHECKLIST

Inspection/Maintenance Activity	Result
1. **DETERMINE** ambient air temperature **AND RECORD** here **AND** in the VCT Operations Log.	45 °F
2. **IF** ambient temperature is < 40°F, **THEN ENSURE** engine block heater, diesel tank heater **AND** hydraulic oil heater are energized for ≥ 30 minutes.	SAT/UNSAT
3. **PERFORM** general walk-around inspection of VCT checking for: • Overall condition **OR** appearance with respect to cleanliness; • Excessive rust **OR** visible cracks on structural members **OR** welds; • Track condition including loose, missing **OR** broken bolting; • Loose, missing **OR** broken bolts/nuts on chassis center section; • Loose, missing **OR** broken bolt/nuts on lift units; • Condition of track undercarriage components **AND** excessive dirtiness; • Fire Extinguisher present with current inspection.	(SAT)/UNSAT
4. **VISUALLY CHECK** track drive seals, track rollers, carrier rollers **AND** front idler units for signs of oil leakage **AND** improper track tension/sag.	(SAT)/UNSAT
5. **CONDUCT** overall engine inspection checking for: • Visible leaks (fuel, oil **OR** coolant); * LEAKY GEAR PUMP POWER UNIT HOSE FITTING OR SEAL RIGHT SIDE OF ENGINE 2/21/16 • Loose or damaged parts **OR** components; • Any visible engine abnormalities **OR** changes.	(SAT)/UNSAT
6. **PERFORM** visual check of air intake components (a) for damaged piping, excessive rusting, loose clamps **OR** hose punctures.	(SAT)/UNSAT
7. **OPEN** air filter rubber clean-out at bottom right of air filter housing **AND**, **IF** needed, **REMOVE** any debris **OR** visible dust/dirt.	(SAT)/UNSAT
8. **CHECK** engine crankcase oil level (b) **AND ADD** oil if needed.	(SAT)/UNSAT
9. **CHECK** hydraulic pump drive oil **AND ADD** oil if needed.	(SAT)/UNSAT
10. **CHECK** fuel level **AND ADD** fuel as needed.	(SAT)/UNSAT
11. **CHECK** engine coolant level (d) **AND ADD** coolant if needed.	(SAT)/UNSAT
12. **INSPECT** engine crankcase breather tube (a) for sludge, debris **OR** ice.	(SAT)/UNSAT
13. **VISUALLY INSPECT** engine drive belt (e).	(SAT)/UNSAT
14. **PERFORM** visual inspection of hydraulic systems checking for: • Hoses **AND** fittings for leaks; • Hydraulic tank oil level with cylinders fully retracted (f) **AND** need to add oil; • Excessive indication of oil (hydraulic or lubricating) at vent for hydraulic pump drive unit (g).	(SAT)/UNSAT
15. **ENSURE** shutoff valves in hydraulic lines from hydraulic oil reservoir to left **AND** right side of drive pump suctions in OPEN position.	(SAT)/UNSAT

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Appendix C - VCT Pre-Use Inspections & Maintenance Checklist (cont'd)

Inspection/Maintenance Activity	Result
16. **ENSURE** shutoff valve in hydraulic line coming from hydraulic oil reservoir to auxiliary hydraulic oil pump suction (h) in OPEN position.	SAT/UNSAT

Notes:

(a) Located on the right side of engine.

(b) VCT engine must be level to provide correct measurement.

(c) Tank has 45 gallon capacity.

(d) Do **NOT** remove radiator cap when water temperature more than 120°F.

(e) Transverse cracks across belt width acceptable but longitudinal cracks that intersect with transverse cracks are unacceptable.

(f) If all cylinders **NOT** fully retracted, complete this inspection following engine start.

(g) Located at top left rear of hydraulic pump housing.

(h) Pump located at lower right-side of engine, near front

Notes/Comments:

* LEAK ON POWER UNIT GEAR PUMP. CLEANED, WILL MONITOR AND DETERMINE IF ADDITIONAL ACTIONS ARE REQUIRED. MKH 2/29/16

Mark K Hunt 2/27/16
Performed By (Sign) (Date)

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TORQUE WRENCH FUNCTIONAL CHECKS

Attach to Work Order package.

Work Order: KW10099709
M&TE Number: 93458-SR.
Model Number: QDFR400
Calibration Due Date: 5-12-16

Determine and circle direction of use (CW) CCW

Using attachment record the torque wrench acceptance criteria. IF the attachment does NOT list the torque wrench acceptance criteria, THEN obtain the accuracy from the Vendor manual. ± 4%

Record the M&TE number the torque wrench is pulled against. 93425.03 (M&TE) 11-25-16 (Cal Due Date)

Verify the M&TE in the previous step has a higher accuracy than the torque wrench. yes.

Record torque values in the PRE and POST tables. Determine the acceptance criteria and record in the PRE and POST tables.

Perform pre-job functional pull check. If torque wrench fails functional check, notify supervision.

Acceptance Criteria		
TEST POINT	**RANGE**	**PRE**
385. ft-lbs	369.5 - 400.4	380.9

Perform a post-job functional check. If torque wrench fails functional check, notify supervision.

Acceptance Criteria		
TEST POINT	**RANGE**	**POST**
385. ft-lbs	369.5 - 400.4	381.6

Comments: _____

Functional Pull Check Performed By: Joe Lomas / Joe Comits (Print / Sign) Initials: JL Date: 2-25-16

Joe Comits / Joe Lomas (Print / Sign) Initials: JL Date: 2-29-16

Supervisor Review: _____ (Print / Sign) Date: _____

Lift Systems, Inc

Cask Transporter Annual Inspection Checklist

Owner/User: NAC INTL. / (W)	Model # CT 201072	Serial # CTS18005
Service Status:	Date: 2-27-16	Technician: MARK K HURST

Status: √ = Satisfactory X = Deficiency R = Recommendation N/A = Does not Apply

Item No.	Item	Status
	Historical Data	
1	Current Annual Inspection	
2	3 Monthly Inspection Records	
3	Maintenance Records	
4	Repair/Modification Records	
5	Load Test Reports	
6	Other	
	General	
7	Sheet Metal	
8	Guards/ Covers	
9	Housekeeping	
10	Safety/Warning Decals	
11	Tagged with weight and capacity	
12	Corrosion	
13	Hydraulic Oil Leaks	X
14	Hours 982.2	√
15	Other	
	Drivers Station	
16	Grab Handles/Steps	
17	Seat Belts	
18	Parking Brake	
19	Controls Identified	
20	Instruments/Gauges	
21	Lights	
22	Steering	
23	Joystick	
24	Seat	
25	Canvas Cover	
26	Other	
27		
	Power plant	
28	Performance	
29	Exhaust System	
30	Belt/Hoses	
31	Guards/Covers	
32	Coolant	
33	Oil	
34	Air Filter	
35	Oil Filter	
36	Fuel Filter	
37	Engine Mounts	
38	Pump Drive	
39	Gear Pump	
40	Fuel Tank	

Item No.	Item	Status
41	Pump Drive Oil Level	
42	Pump Drive Hardware	
43	Other	
	Left Track Drive & Frame	
44	Shoe Bolts	
45	Gear Boxes	
46	Track Adjustment	
47	Bearings	
48	Side Frame Bolts	
49	Motors	
50	Brakes	
51	Filter	
52	Operating Pressure	
53	Charge Pressure	
54	Leaks	
55	Welds	
56	Pump	
57	Strobe Light	
58	Back up Alarm	
59	Railings	
60	Strap Cylinder	
61	Other	
	Right Track Drive & Frame	
62	Shoe Bolts	
63	Gear Boxes	
64	Track Adjustment	
65	Bearings	
66	Side Frame Bolts	
67	Motors	
68	Brakes	
69	Filter	
70	Operating Pressure	
71	Charge Pressure	
72	Leaks	
73	Welds	
74	Pump	
75	Railings	
76	Other	
	Center Section	
77	Welds	
78	Bolts	
79	Ladder	
80	Railing	
81	Hoses	

Lift Systems, Inc

Owner/User: NAC Intl / (W)	Model # CT20072	Serial # CTC 18 0005

Status: √ = Satisfactory X = Deficiency R = Recommendation N/A = Does not Apply

Item No.	Item	Status
	Left Tower	
82	Welds	
83	Leaks	
84	Wedges	
85	Locking Pins	
86	Slider Pads	
87	Hoses	
88	Counter Balance Valve Settings	
89	Mounting Bolts	
90	Electrical Components	
91	Bolt Torque	
92	Other Dry Film Lubricant	✓
	Right Tower	
93	Welds	
94	Leaks	
95	Wedges	
96	Locking Pins	
97	Slider Pads	
98	Hoses	
99	Counter Balance Valve Settings	
100	Mounting Bolts	
101	Electrical Components	
102	Bolt Torque	
103	Other Dry Film Lubricant	✓
	Power Unit	
104	Welds	
105	Leaks	
106	Hydraulic oil Level	
107	Return Filter	
108	Control Valve	
109	Hoses	
110	Breather	
111	Strobe Light	
112	Relief Valves	
113	Control Valve pressures	
114	Tank Heater	
115	Other	

Item No.	Item	Status
	Link Positoners and Beams	
116	Welds	
117	Cylinders	
118	Hoses	
119	Leaks	
120	Hose Reels	
121	Bolt Torque	✓
122	Slider Pads	
123	Other	
	Misc.	
124	Lights	
125	Gauges	
126	Additional E-Stops	
127	Slings and Straps	
128	Strap Cylinder	
129	Strap Fittings	
130	Bumpers	
131	Lifting pins	
132	Electrical enclosures	
133	Optional Winch	
134	Height Transducers(CARL)	
135	Pressure Transducers(CARL	
136	Display(CARL)	
137	Modules(CARL)	
138	Wire Harnesses	
139	Coolers	

Lift Systems, Inc

Owner/User: NAC Intl. / (W)	Model #CT201072	Serial # CTC 18005

Status: √ = Satisfactory X = Deficiency R = Recommendation N/A = Does not Apply

No Load Function Test

Extend Left:	Retract Left:	Extend Right:	Retract Right:	Extend Both:
Retract Both:	Wedges Set:	Wedges Release:	Lt. Lift Link Ext:	
Rt. Lift Link Ext:	Lt. Lift Link Ret:	Rt. Lift Link Ret:		
Both Lift Link Ext:	Both Lift Link Ret:	Strap Cylinder Ext:		
Strap Cylinder Ret:	Travel For:	Travel Rev:	Travel Left:	Travel Right:
Travel Tracking:	Brakes:			

Load Test

Stage	Rated Capacity		Test Weight		% of Rated Capacity
First Stage					
Second Stage					

PASS	N/A	FAIL	EXPLANATION:

Deficiency/ Recommendation Report

Date:	Owner/User:	Unit:

The following corrective action(s) (repairs, adjustments, replacement parts, etc.) are to be performed by a qualified person in accordance with all manufacturer's instructions, specifications, and requirements. OSHA requires that, "any deficiency shall be repaired or defective parts replaced before continued use."Recommendation(s) should be considered for corrective action. The advisability of a particular recommendation depends on the facts in each situation. Any corrective action(s) is to be performed by a qualified person in accordance with all manufacturer's recommendations, specifications, and requirements. All Recommendations and Deficiencies resulting from inspection have been explained by inspector.

D = Deficiency R = Recommendation

D/R	Item No.	Explanation	Signature of Representative once in compliance.	Date
D	13	LEAK ON POWERUNIT GEAR PUMP		
R	13	MONITOR TO DETERMINE IF FURTHER ACTION IS NEEDED. TIGHTENED 2-18-16. CLEANED 2-27-16, OF RESIDUAL HYDRAULIC FLUID.		

Lift Systems, Inc

Owner/User:	Model #	Serial #

D/R	Item No.	Explanation	Signature of Representative once in compliance.	Date

Lift Systems, Inc

Cask Transporter Annual Inspection Checklist

Owner/User: NAC International		Model #CT201072	Serial # CTC180005
Service Status:	Date: 2-18-16	Technician: Rick Williams	

Status: √ = Satisfactory X = Deficiency R = Recommendation N/A = Does not Apply

Item No.	Item	Status
Historical Data		
1	Current Annual Inspection	√
2	3 Monthly Inspection Records	√
3	Maintenance Records	√
4	Repair/Modification Records	√
5	Load Test Reports	
6	Other	
General		
7	Sheet Metal	√
8	Guards/ Covers	√
9	Housekeeping	√
10	Safety/Warning Decals	√
11	Tagged with weight and capacity	√
12	Corrosion	√
13	Hydraulic Oil Leaks	X
14	Hours 982	√
15	Other	
Drivers Station		
16	Grab Handles/Steps	√
17	Seat Belts	√
18	Parking Brake	√
19	Controls Identified	√
20	Instruments/Gauges	√
21	Lights	√
22	Steering	√
23	Joystick	√
24	Seat	√
25	Canvas Cover	√
26	Other	
27		
Power plant		
28	Performance	√
29	Exhaust System	√
30	Belt/Hoses	√
31	Guards/Covers	√
32	Coolant	√
33	Oil	√
34	Air Filter	√
35	Oil Filter	√
36	Fuel Filter	√
37	Engine Mounts	√
38	Pump Drive	√
39	Gear Pump	√
40	Fuel Tank	√

Item No.	Item	Status
41	Pump Drive Oil Level	√
42	Pump Drive Hardware	√
43	Other	
Left Track Drive & Frame		
44	Shoe Bolts	√
45	Gear Boxes	√
46	Track Adjustment	√
47	Bearings	√
48	Side Frame Bolts	√
49	Motors	√
50	Brakes	√
51	Filter	√
52	Operating Pressure	√
53	Charge Pressure	√
54	Leaks	√
55	Welds	√
56	Pump	√
57	Strobe Light	√
58	Back up Alarm	√
59	Railings	√
60	Strap Cylinder	√
61	Other	
Right Track Drive & Frame		
62	Shoe Bolts	√
63	Gear Boxes	√
64	Track Adjustment	√
65	Bearings	√
66	Side Frame Bolts	√
67	Motors	√
68	Brakes	√
69	Filter	√
70	Operating Pressure	√
71	Charge Pressure	√
72	Leaks	√
73	Welds	√
74	Pump	√
75	Railings	√
76	Other	
Center Section		
77	Welds	√
78	Bolts	√
79	Ladder	√
80	Railing	√
81	Hoses	√

1505 7th Street
East Moline, IL 61244

Phone: 309-764-9842
Fax: 309-752-1875

Lift Systems, Inc

Owner/User:	Model #	Serial #

Status: √ = Satisfactory X = Deficiency R = Recommendation N/A = Does not Apply

Item No.	Item	Status
	Left Tower	
82	Welds	✓
83	Leaks	✓
84	Wedges	✓
85	Locking Pins	N/A
86	Slider Pads	✓
87	Hoses	✓
88	Counter Balance Valve Settings	N/A
89	Mounting Bolts	✓
90	Electrical Components	✓
91	Bolt Torque	✓
92	Other	
	Right Tower	
93	Welds	✓
94	Leaks	✓
95	Wedges	✓
96	Locking Pins	N/A
97	Slider Pads	✓
98	Hoses	✓
99	Counter Balance Valve Settings	N/A
100	Mounting Bolts	✓
101	Electrical Components	✓
102	Bolt Torque	✓
103	Other	
	Power Unit	
104	Welds	✓
105	Leaks	X
106	Hydraulic oil Level	X
107	Return Filter	✓
108	Control Valve	✓
109	Hoses	✓
110	Breather	✓
111	Strobe Light	✓
112	Relief Valves	N/A
113	Control Valve pressures	✓
114	Tank Heater	✓
115	Other	

Item No.	Item	Status
	Link Positoners and Beams	
116	Welds ✓	✓
117	Cylinders ✓	✓
118	Hoses ✓	✓
119	Leaks ✓	✓
120	Hose Reels ✓	✓
121	Bolt Torque	X
122	Slider Pads	✓
123	Other	
	Misc.	
124	Lights	✓
125	Gauges	✓
126	Additional E-Stops	✓
127	Slings and Straps	✓
128	Strap Cylinder	✓
129	Strap Fittings	✓
130	Bumpers	✓
131	Lifting pins	✓
132	Electrical enclosures	✓
133	Optional Winch	N/A
134	Height Transducers(CARL)	✓
135	Pressure Transducers(CARL	✓
136	Display(CARL)	✓
137	Modules(CARL)	✓
138	Wire Harnesses	✓
139	Coolers	N/A

Lift Systems, Inc

Owner/User: NAC	Model # CT20/072	Serial # CTC 18000 C

Status: √ = Satisfactory X = Deficiency R = Recommendation N/A = Does not Apply

No Load Function Test

Extend Left: ✓	Retract Left: ✓	Extend Right: ✓	Retract Right: ✓	Extend Both: ✓
Retract Both: ✓	Wedges Set: ✓	Wedges Release: ✓	Lt. Lift Link Ext: ✓	
Rt. Lift Link Ext: ✓	Lt. Lift Link Ret: ✓	Rt. Lift Link Ret: ✓		
Both Lift Link Ext: ✓	Both Lift Link Ret: ✓	Strap Cylinder Ext: ✓		
Strap Cylinder Ret: ✓	Travel For: ✓	Travel Rev ✓	Travel Left: ✓	Travel Right: ✓
Travel Tracking: ✓	Brakes: ✓			

Load Test

Stage	Rated Capacity		Test Weight		% of Rated Capacity
First Stage					
Second Stage					

PASS	N/A	FAIL	EXPLANATION:

Deficiency/ Recommendation Report

Date:	Owner/User:	Unit:

The following corrective action(s) (repairs, adjustments, replacement parts, etc.) are to be performed by a qualified person in accordance with all manufacturer's instructions, specifications, and requirements. OSHA requires that, "any deficiency shall be repaired or defective parts replaced before continued use."Recommendation(s) should be considered for corrective action. The advisability of a particular recommendation depends on the facts in each situation. Any corrective action(s) is to be performed by a qualified person in accordance with all manufacturer's recommendations, specifications, and requirements. All Recommendations and Deficiencies resulting from inspection have been explained by inspector.

D = Deficiency R = Recommendation

D/R	Item No.	Explanation	Signature of Representative once in compliance.	Date
D	13	leak on Power unit Gear pump		
R	13	tighten Fitting on Pump if leak continues the Fitting may need replaced	Rick Medlin/Mark	2-18-16
D	121	Beam Bolts not checked due to lack of man Lift At First Chance torque to 385 ft lbs	Mark K Hunt	2-27-16

Lift Systems, Inc

Owner/User:	Model #	Serial #

D/R	Item No.	Explanation	Signature of Representative once in compliance.	Date

Document is NOT VALID unless signed by BOTH "Technician" and "Representative" below

Technician: Richard McMillan

Company Representative: Mark K Hirst 02/18/16

FORM# QSF086 rev 000 Date 4/2012

1505 7th Street
East Moline, IL 61244

Phone: 309-764-9842
Fax: 309-752-1875

Email: liftit@lift-systems.com
Web: lift-systems.com

CALIBRATION CERTIFICATE

HYDRAULIC TORQUE WRENCH

TorcUP, Inc.
1025 Conroy Place, Easton, PA 18040
Tel: (610) 250-5800 Fax: (610) 250-2700
www.TorcUP.com

Date: Thursday, June 11, 2015

Certification No.: J-15 TU3-1001-06

Company: LIFT SYSTEMS
1505 7TH STREET
EAST MOLINE IL 61244

Model #: TU-3

Serial #: TU3-1001-06

Procedure # TCI012

Torque Range NM: 530 - 4933

Accuracy: +3% Set torque

Recall Interval 1 Year

Temperature: 76 °F

Humidity: 39%

Calibration Due: 11-Jun-2016

LABORATORY ACCREDITATION BUREAU a division of A2LA ACCREDITED ISO/IEC 17025
Certificate # L2366 Calibration

Applied Pressure	As Found Torque	As Left Torque
Bar	NM	NM
69	519	530
76	566	578
83	613	625
90	660	672
97	707	719
103	754	767
110	801	814
117	848	861
124	895	909
131	942	956

Applied Pressure	As Found Torque	As Left Torque
Bar	NM	NM
138	989	1003
145	1038	1052
152	1086	1100
159	1135	1148
165	1183	1197
172	1231	1245
179	1280	1293
186	1328	1341
193	1377	1390
200	1425	1438

Applied Pressure	As Found Torque	As Left Torque
Bar	NM	NM
207	1474	1486
214	1520	1536
221	1567	1586
228	1614	1635
234	1661	1685
241	1708	1735
248	1755	1785
255	1802	1834
262	1846	1884
269	1895	1934

Applied Pressure	As Found Torque	As Left Torque
Bar	NM	NM
276	1942	1983
283	1991	2032
290	2040	2081
296	2090	2130
303	2139	2179
310	2188	2228
317	2237	2277
324	2286	2326
331	2335	2374
338	2384	2423

Applied Pressure	As Found Torque	As Left Torque
Bar	NM	NM
345	2433	2472
352	2483	2522
359	2533	2571
365	2583	2620
372	2633	2670
379	2683	2719
386	2733	2769
393	2782	2818
400	2832	2867
407	2882	2917

Applied Pressure	As Found Torque	As Left Torque
Bar	NM	NM
414	2932	2966
421	2983	3015
427	3033	3063
434	3084	3112
441	3134	3160
448	3185	3209
455	3235	3257
462	3286	3306
469	3336	3354
476	3387	3402

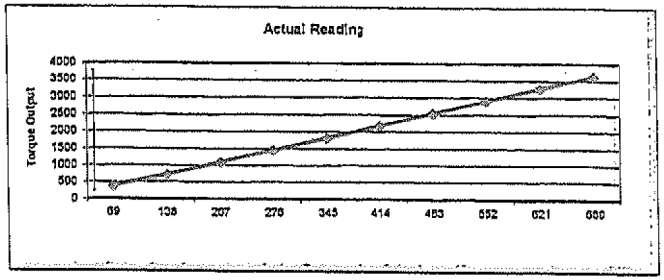
Applied Pressure	As Found Torque	As Left Torque
Bar	NM	NM
483	3438	3451
490	3487	3500
496	3537	3549
503	3587	3598
510	3636	3648
517	3686	3697
524	3736	3746
531	3785	3795
538	3835	3844
545	3885	3893

Applied Pressure	As Found Torque	As Left Torque
Bar	NM	NM
552	3935	3942
558	3984	3992
565	4034	4042
572	4084	4092
579	4134	4142
586	4184	4192
593	4233	4242
600	4283	4292
607	4333	4342
614	4383	4392

Applied Pressure	As Found Torque	As Left Torque
Bar	NM	NM
621	4433	4442
627	4482	4491
634	4532	4540
641	4582	4589
648	4632	4638
655	4681	4688
662	4731	4737
669	4781	4786
676	4830	4835
683	4880	4884

Applied Pressure	As Found Torque	As Left Torque
Bar	NM	NM
689	4930	4933

Manufacturer	Model No.	Serial No.
Norbar	43228 TTT Series 3	79058
Cal. Date: 31-Mar-15	Cal. Due:	31-Mar-16
Manufacturer	Model No.	Serial No.
Norbar	50630	78918
Cal. Date: 31-Mar-15	Cal. Due:	31-Mar-16
Manufacturer	Model No.	Serial No.
Crystal Engineering	15KPSIXP2i	471340
Cal. Date: 22-Oct-14	Cal. Due:	22-Oct-15
Manufacturer	Model No.	Serial No.
Control Company	4380 Display	111762102
Cal. Date: 14-Nov-13	Cal. Due:	14-Nov-15
Manufacturer	Model No.	Serial No.
Control Company	4381 Transmitter	130717730
Cal. Date: 14-Nov-13	Cal. Due:	14-Nov-15



TorcUP Inc. certifies that this tool has been calibrated using standards listed.
The calibration certificates are traceable through NIST or another National Metrology Institute to the International System of Units (SI Units).
TorcUP calibrates TU Series tools from 1,000psi to 10,000psi in 1,000psi increments. All other values are interpolated.
This certificate shall not be reproduced, except in full, without written approval of TorcUP Inc.
Recall intervals are determined by the End User
Measurement Uncertainties listed are approximately a 95% confidence level using a coverage factor of k=2.
The measurement uncertainty is 0.65%

Inspector: Theodore Bill

CALIBRATION
I.D. No. 150605
By Torque Date 6/11/15
Due 6/11/16

CALIBRATION CERTIFICATE

HYDRAULIC TORQUE WRENCH

ToreUP, Inc.
1025 Conroy Place, Easton, PA 18040
Tel: (610) 250-5800 Fax: (610) 250-2700
www.TorcUP.com

Date: Thursday, June 11, 2015

Certification No.: J-15 TU3-1001-06

Company: LIFT SYSTEMS
1505 7TH STREET
EAST MOLINE IL 61244

Model #: TU-3

Serial #: TU3-1001-06

Procedure # TCI012

Torque Range FT/LB: 391 - 3638

Accuracy: + 3% Set Torque

Recall Interval 1 Year

Temperature: 76 °F

Humidity: 39%

Calibration Due: 11-Jun-2016

LABORATORY ACCREDITATION BUREAU a division of A2LA
ACCREDITED ISO/IEC 17025
Certificate # L2366 Calibration

Applied Pressure	As Found Torque	As Left Torque
PSI	FT/LB	FT/LB
1000	383	391
1100	417	426
1200	452	461
1300	487	496
1400	521	531
1500	556	566
1600	591	600
1700	626	635
1800	660	670
1900	695	705

Applied Pressure	As Found Torque	As Left Torque
PSI	FT/LB	FT/LB
2000	730	740
2100	765	776
2200	801	811
2300	837	847
2400	873	883
2500	908	918
2600	944	954
2700	980	989
2800	1015	1025
2900	1051	1061

Applied Pressure	As Found Torque	As Left Torque
PSI	FT/LB	FT/LB
3000	1087	1096
3100	1121	1133
3200	1156	1170
3300	1191	1206
3400	1225	1243
3500	1260	1280
3600	1294	1316
3700	1329	1353
3800	1363	1390
3900	1398	1426

Applied Pressure	As Found Torque	As Left Torque
PSI	FT/LB	FT/LB
4000	1433	1463
4100	1469	1499
4200	1505	1535
4300	1541	1571
4400	1577	1607
4500	1614	1643
4600	1650	1679
4700	1686	1715
4800	1722	1751
4900	1759	1787

Applied Pressure	As Found Torque	As Left Torque
PSI	FT/LB	FT/LB
5000	1795	1823
5100	1832	1860
5200	1868	1896
5300	1905	1933
5400	1942	1969
5500	1979	2006
5600	2015	2042
5700	2052	2078
5800	2089	2115
5900	2125	2151

Applied Pressure	As Found Torque	As Left Torque
PSI	FT/LB	FT/LB
6000	2163	2188
6100	2200	2224
6200	2237	2259
6300	2274	2295
6400	2312	2331
6500	2349	2367
6600	2386	2402
6700	2424	2438
6800	2461	2474
6900	2498	2510

Applied Pressure	As Found Torque	As Left Torque
PSI	FT/LB	FT/LB
7000	2535	2545
7100	2572	2582
7200	2609	2618
7300	2645	2654
7400	2682	2690
7500	2719	2727
7600	2755	2763
7700	2792	2799
7800	2829	2835
7900	2866	2871

Applied Pressure	As Found Torque	As Left Torque
PSI	FT/LB	FT/LB
8000	2902	2908
8100	2939	2945
8200	2975	2981
8300	3012	3018
8400	3049	3055
8500	3086	3092
8600	3122	3129
8700	3159	3166
8800	3196	3203
8900	3233	3240

Applied Pressure	As Found Torque	As Left Torque
PSI	FT/LB	FT/LB
9000	3269	3276
9100	3306	3313
9200	3343	3349
9300	3379	3385
9400	3416	3421
9500	3453	3457
9600	3489	3494
9700	3526	3530
9800	3563	3566
9900	3599	3602

Applied Pressure	As Found Torque	As Left Torque
PSI	FT/LB	FT/LB
10000	3636	3638

Manufacturer	Model No.	Serial No.
Norbar	43228 TTT Series 3	79058
Cal. Date: 31-Mar-15	Cal. Due:	31-Mar-16
Manufacturer	Model No.	Serial No.
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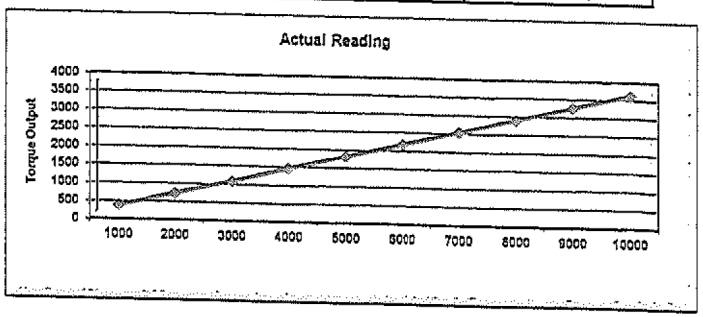

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The measurement uncertainty is 0.65%

Inspector: Theodore Bill

CALIBRATION
I.D. No. E0693
By ToreUP Date 6/11/15
Due 6/11/16

Cert #: 61823-7

ISO 9001:2008 F53692

Quad City Calibration
DBA Quad City Testing Laboratory, Inc.
21112 Scott Park Road
Davenport, Iowa 52807
(800) 391-8501

CERTIFICATE of CALIBRATION

Customer Name: LIFT SYSTEMS
Job #: 61823
Address:
PO #: LS58138
1505 7TH ST
City/State/Zip: EAST MOLINE, IL 61244

Description: TORQUE 250-700 FT LBS
Serial #: E0729
Testing Date: 12/11/2015
Recalibration Date: 12/11/2016

Traceability: Results are traceable to NIST#: 821/276375-08, 822/272103-05 Acceptance standard per ISO 6789 +/- 4% clockwise +/- 6% counter clockwise type. +/- 4% both directions beam or dial type which are tracable to NIST. Environmental state 68 degrees, 40% R.H.

Required	Cw Before	P/F	Cw After	P/F	Ccw Before	P/F	Ccw After	P/F
200	195.3	P	195.3	P				
300	295.0	P	295.0	P				
400	398.6	P	398.6	P				
500	491.4	P	491.4	P				
600	577.6	P	577.6	P				

Transducer Used: 5

Comments: WITHIN REQUIRED ACCURACY.

Dillon Morley AO

Technician: Dillon Morley

Date: 12/11/2015 Process Number: P-087-B Gage Cond.: GOOD

This certificate may not be reproduced, except in full, without the written approval of QCC.

Cert #: 61823-6

ISO 9001:2008 F53692

Quad City Calibration
DBA Quad City Testing Laboratory, Inc.
21112 Scott Park Road
Davenport, Iowa 52807
(800) 391-8501

CERTIFICATE of CALIBRATION

Customer Name: LIFT SYSTEMS
Job #: 61823
Address: 1505 7TH ST
PO #: LS58138
City/State/Zip: EAST MOLINE, IL 61244

Description: TORQUE 1-250 FT LBS
Serial #: E0730
Testing Date: 12/11/2015
Recalibration Date: 12/11/2016

Traceability: Results are traceable to NIST#: 821/276375-08, 822/272103-05 Acceptance standard per ISO 6789 +/- 4% clockwise +/- 6% counter clockwise type. +/- 4% both directions beam or dial type which are tracable to NIST. Environmental state 68 degrees, 40% R.H.

Required	Cw Before	P/F	Cw After	P/F	Ccw Before	P/F	Ccw After	P/F
50	49.94	P	49.94	P				
100	98.32	P	98.32	P				
150	147.9	P	147.9	P				
200	192.8	P	192.8	P				
250	244.4	P	244.4	P				

Transducer Used: 4

Comments: WITHIN REQUIRED ACCURACY.

Technician: Dillon Morley

Date: 12/11/2015 Process Number: P-087-B Gage Cond.: GOOD

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Section 12.0
Operational Manual
(with recommended spares)

Submitted Separately