

Attachment D

Scope of Work

Lightning Mitigation System

General

The following Scope of Work is to test the integrity of the Complex 40 catenary system and lightning protection system. The system consists of four towers, each 340 total feet. Total height consisted of the 264ft steel tower and 76ft fiber reinforce plastic (FRP) mast, surrounding the launch mount, and a series of grounding wires from the towers to down conductor grounding rods and anchors located around the complex.

Scope of Work

Contractor shall be responsible for:

- Overall safety of the operation and personnel
- Direct all tasks associated with the operation
- Verify qualifications of all personnel involved

Provide a report covering, but not limited to, the following to the contracting officer for disposition:

1. A written procedure of the task for Owner(SpaceX) review and approval (to include suggested annual maintenance procedure)
2. A visual inspection report of the towers per TIA/EIA 222 to include:
 - a) Legs, braces, bolts, welds, flanges, drain holes, ladder, ladder safety rail for corrosion or damage.
 - b) At the down conductor ground wire, inspect insulator, anchor bolts, shafts, equalizer plates, clevises and shackles, bolts and welds for overall condition and presence of corrosion or damage
 - c) Inspect the upper cable array, ground wires and associated turnbuckles and cable clamps for physical condition and damage.
 - d) Inspect the winch located at the top of the FRP mast.
3. Tensioning of the catenary system using the following:

- a) Perform a tension check on the down conductor ground wires connected to this tower. Record tension in table 6.1 using Table 6.2, Figure 6.1, and Figure 6.2 for reference
 - b) Pad temperature and wind speed data retrieved from the west tower data-logger. Add temperature data to column 5 and wind speed data to column 9 based on time recorded in column 4 of Table 6.1.
 - c) Complete Table 6.1 calculations
 - d) Adjust tension on cables if tension tolerance is less than 250 lbs or greater than 650 lbs (at 75 deg F).
4. Measurement of resistance between
- a) Each catenary cable guy wire and the lightning rod air terminal (on top of candlestick mast) (Record in Table 6.3)
 - b) Each catenary cable guy wire and the ground rod (at bottom of guy wire) (Record in Table 6.3)
 - c) Review Table 6.3; repair any connections with resistance measurements greater than 1 Ohm.
 - d) Review table 6.4; repair any ground rods with ground resistance measurements greater than 1 Ohm.
 - e) Each ground plate earth ground resistance (clamp meter ground loop reading) and record in Table 6.4.
5. Corrosion Control:
- As the basic requirements, perform the following corrosion control and repair.. All other corrosion related findings identified in scope number 2 above, will be based on the direction of the contracting officer. All steel components and steel fasteners in the mast-tower interface supporting area and the top mast ring area shall be prepared, touch up repair, and/or new paint in according to NASA-STD-5008 Zone 2 color to match existing.
- a) Perform corrosion control repair for the stainless steel Cable Mast Ring at the top of the FRP mast (candle stick) and replace(replace one at time) all corroded fastener that secures the stainless steel cable array mast ring to the FRP mast, apply Loctite 262 to thread. See Figure 6.3 and picture 1 & 2.
 - b) Perform corrosion control to the steel collar stiffener rings and surround support steel members at the base of the candle stick (figure 6.4) and its fastener. If required replace corroded damaged steel member and associated fastener. Touch up repair and/or new paint on steel and fastener. All replacement shall be fabricated or procured to match with existing tower member and fastener (provide temporary support/brace during steel member replacement). See figure 6.5 thru 6.9 and picture 3 &4.

Table 6.1 Lightning Protection System Down Conductor Tension Table

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	
Cable	Required Tension (LBS) at 75 deg F	Dial Indicator Reading (LBS)	Measured Tension (LBS)	Time	Temp (Deg F)	Temp Adjusted Factor (Table 2)	Temp Adjusted Tension (LBS)	Difference (Required – Temp Adjusted, LBS)	Wind Speed (MPH)
							Equals Column 3 Divided by Column 6	Equals Column 7 minus Column 1	
A-A3	5750								
C-A3	2250								
C-B3	2250								
AA-A3	2250								
D-A3	2250								
D-B3	2250								
G-B3	5750								
H-B2	5750								
K-B2	2250								
K-A2	2250								
BB-B2	2250								
L-B2	2250								
L-A2	2250								
N-A2	5750								

Tension taken at lower end of cable. Tension tolerance at 75 deg F: -250 / +650 lbs

Table 6.2: Guy Wire Tensions Temperature Adjusted Factor

Temp (Deg F)	¼	5/16	3/8	7/16	½	9/16	5/8	¾	7/8	1
120	501	874	1212	1588	2066	2700	3270	4620	6280	10050
90	583	997	1376	1834	2378	3100	3760	5220	7130	11120
60	665	1120	1540	2080	2690	3500	4240	5830	7970	12200
30	747	1243	1704	2325	3002	3900	4720	6440	8870	13280
0	828	1366	1868	2572	3314	4300	5210	7040	9660	14350

Table 6.3: Resistance Measurements

Cable	Resistance Measurements (ohms)	
	Resistance to Ground Rod	Resistance to Air Terminal (At Top of Tower)
A-A3		
C-A3		
C-B3		
AA-A3		
D-A3		
D-B3		
G-B3		
H-B2		
K-B2		
K-A2		

Table 6.4: Ground Rod Resistance Measurements

Cable	Ground Resistance (Ohms)
A-A3	
C-A3	
C-B3	
AA-A3	
D-A3	
D-B3	
G-B3	
H-B2	
K-B2	
K-A2	

Figure 6.1: Cable System Schematic

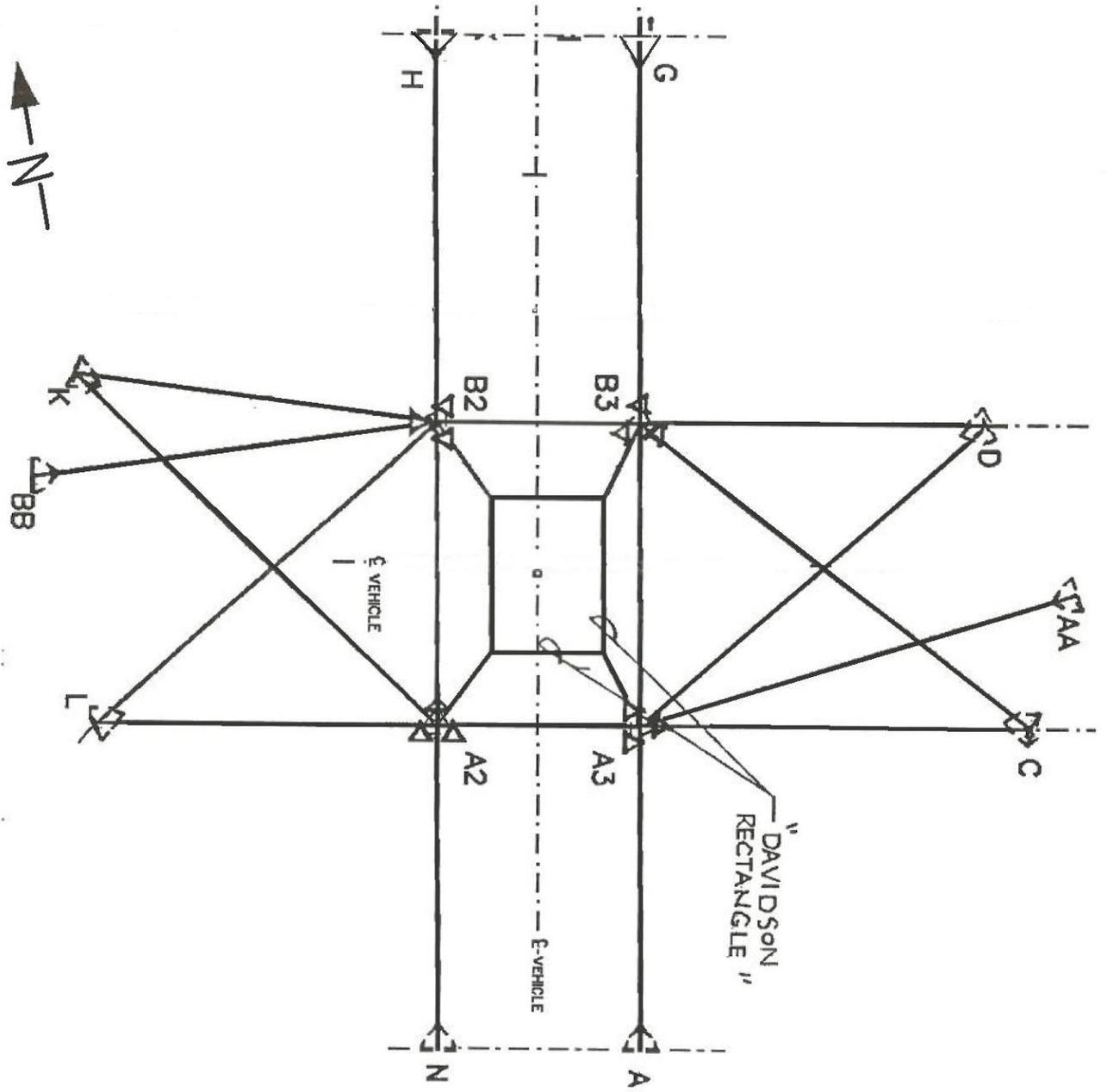
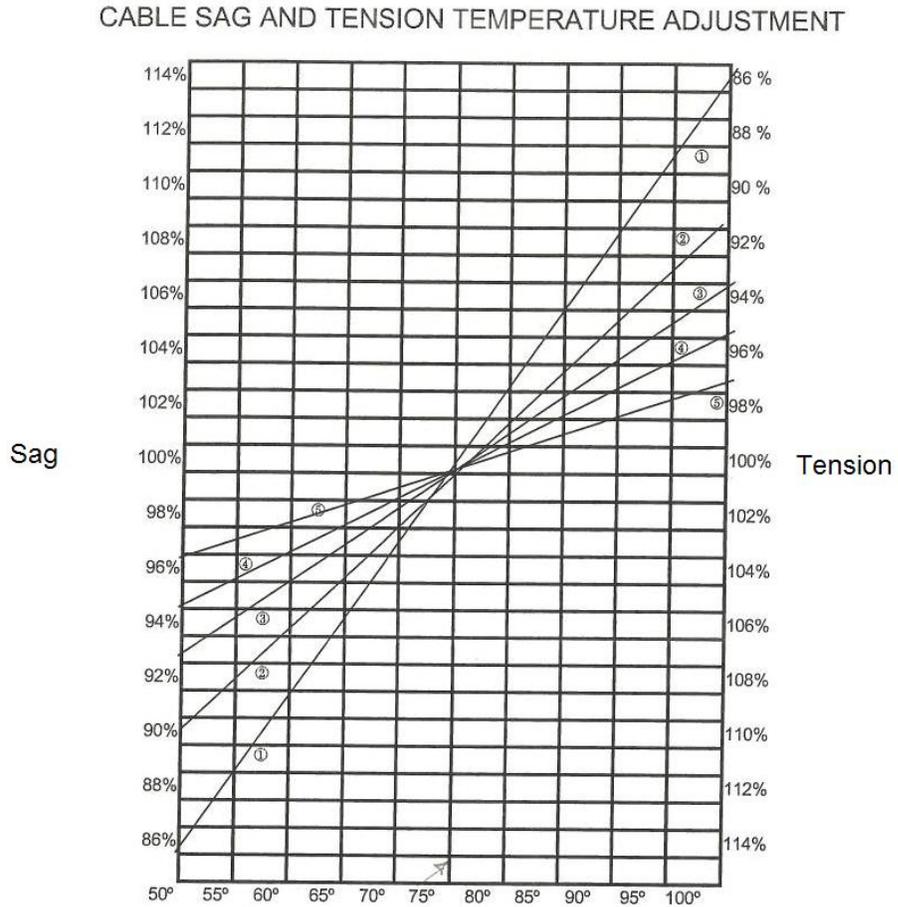


Figure 6.2: Cable Sag and Tension Temperature Adjustment



Note

Tension and sag shown correspond to ambient temperature of 75° F. If the ambient temperature at time of cable installation is different than 75° F, adjust the tension and sag in accordance with the above chart

Figure 6.4: FRP Mast-Tower Interface

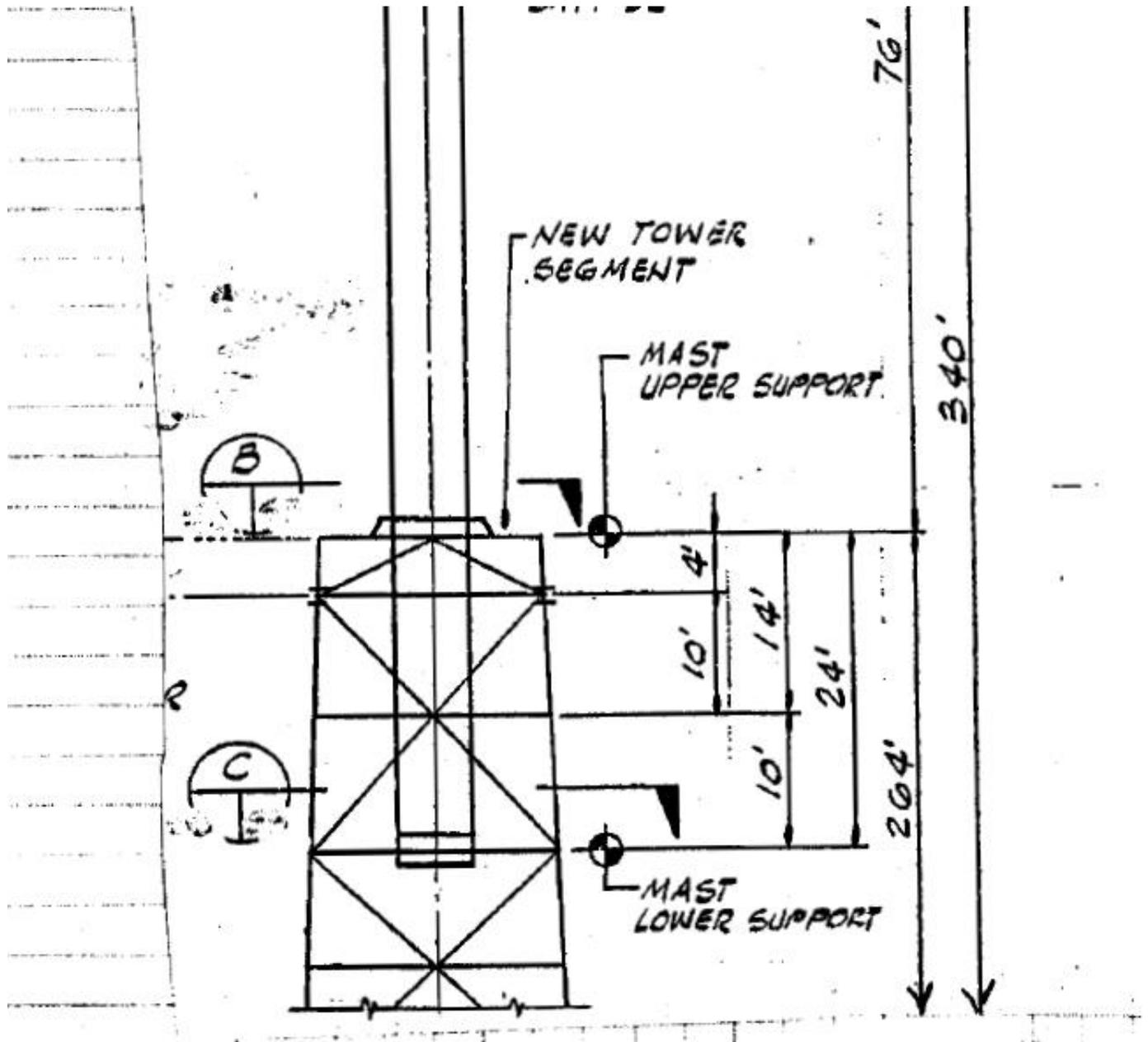


Figure 6.5: Mast Upper Support Plan (View B)

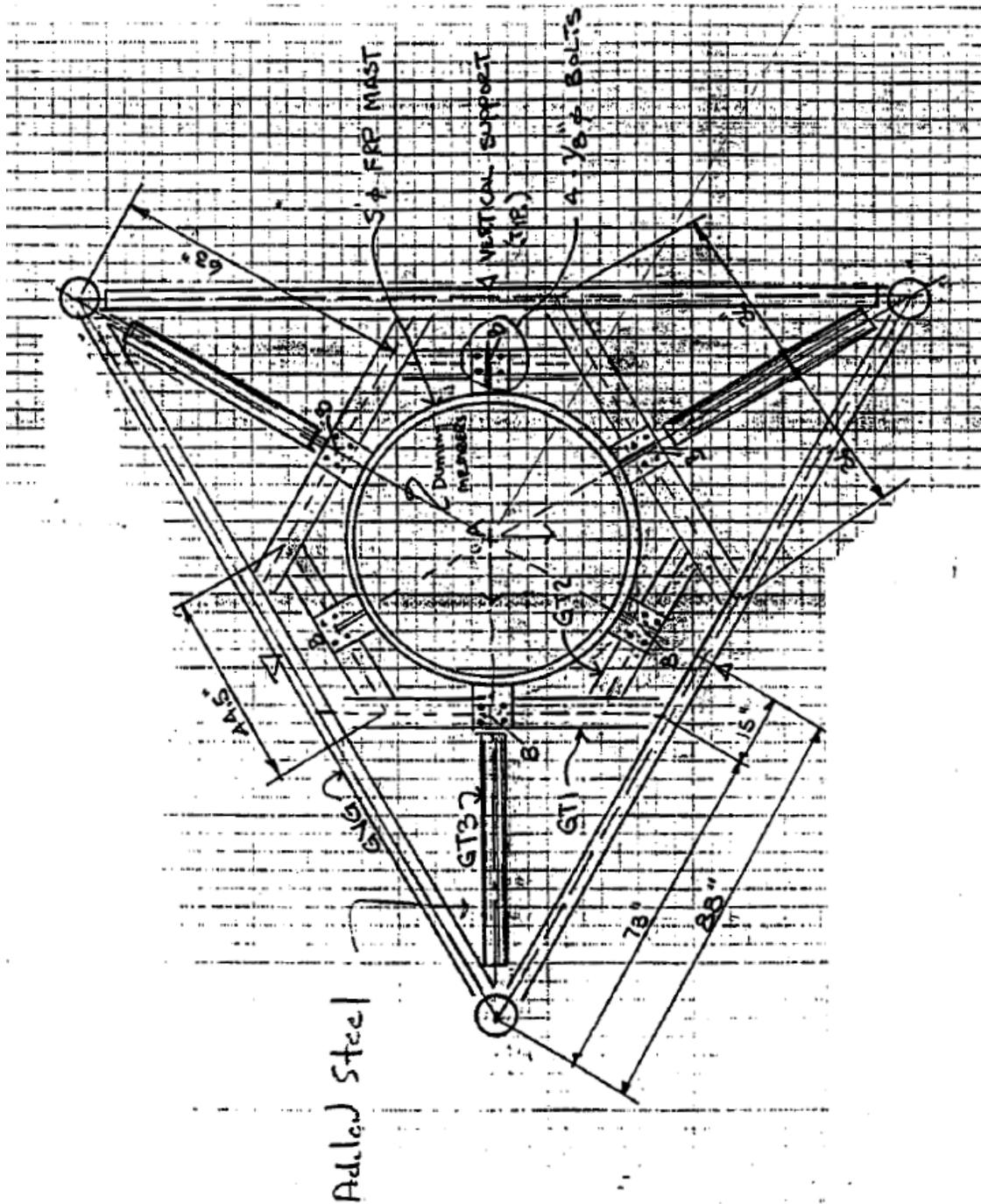


Figure 6.7: Section A Mast Upper Support Connection Detail

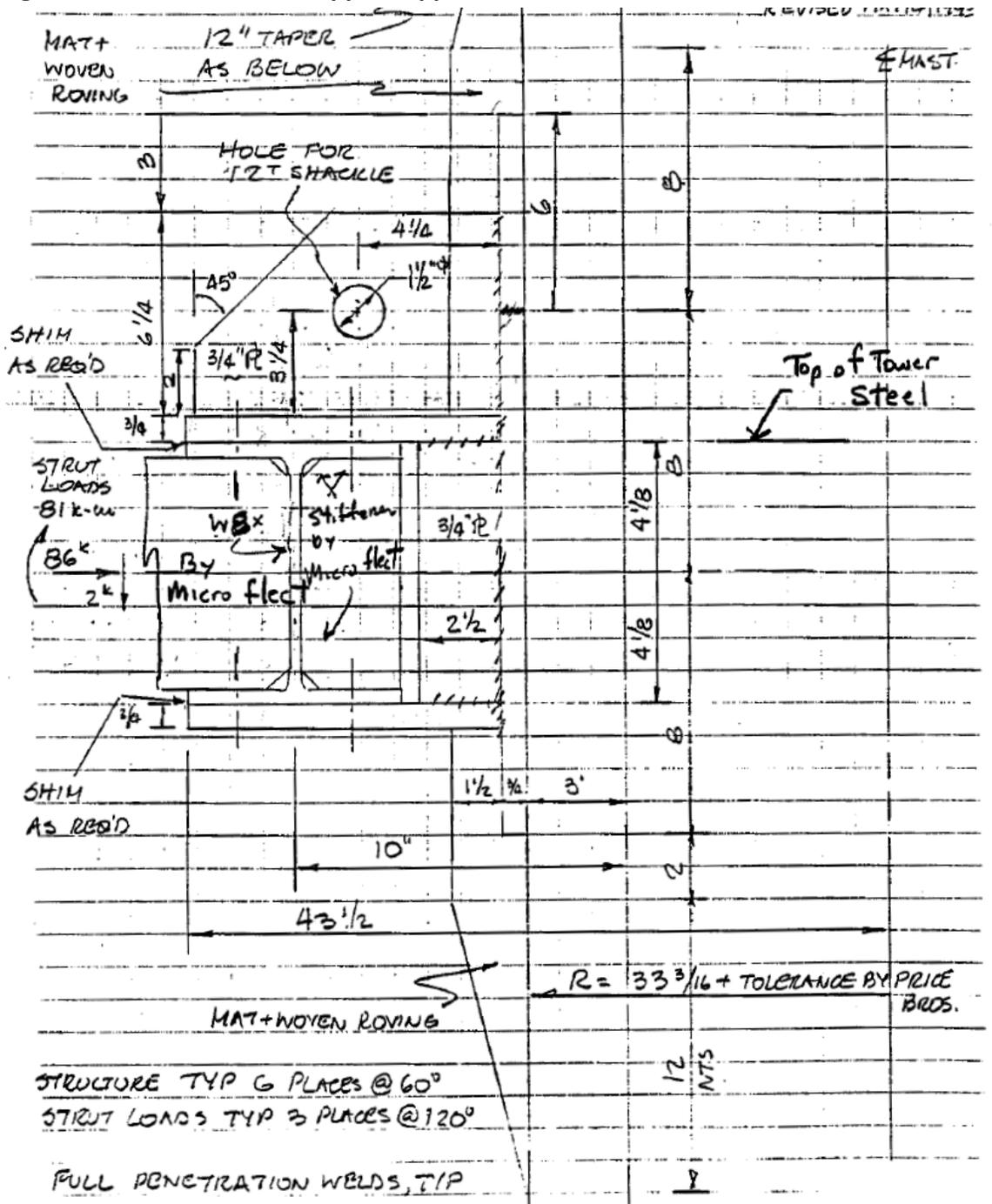


Figure 6.8: Section B Mast Upper Support Connection Detail

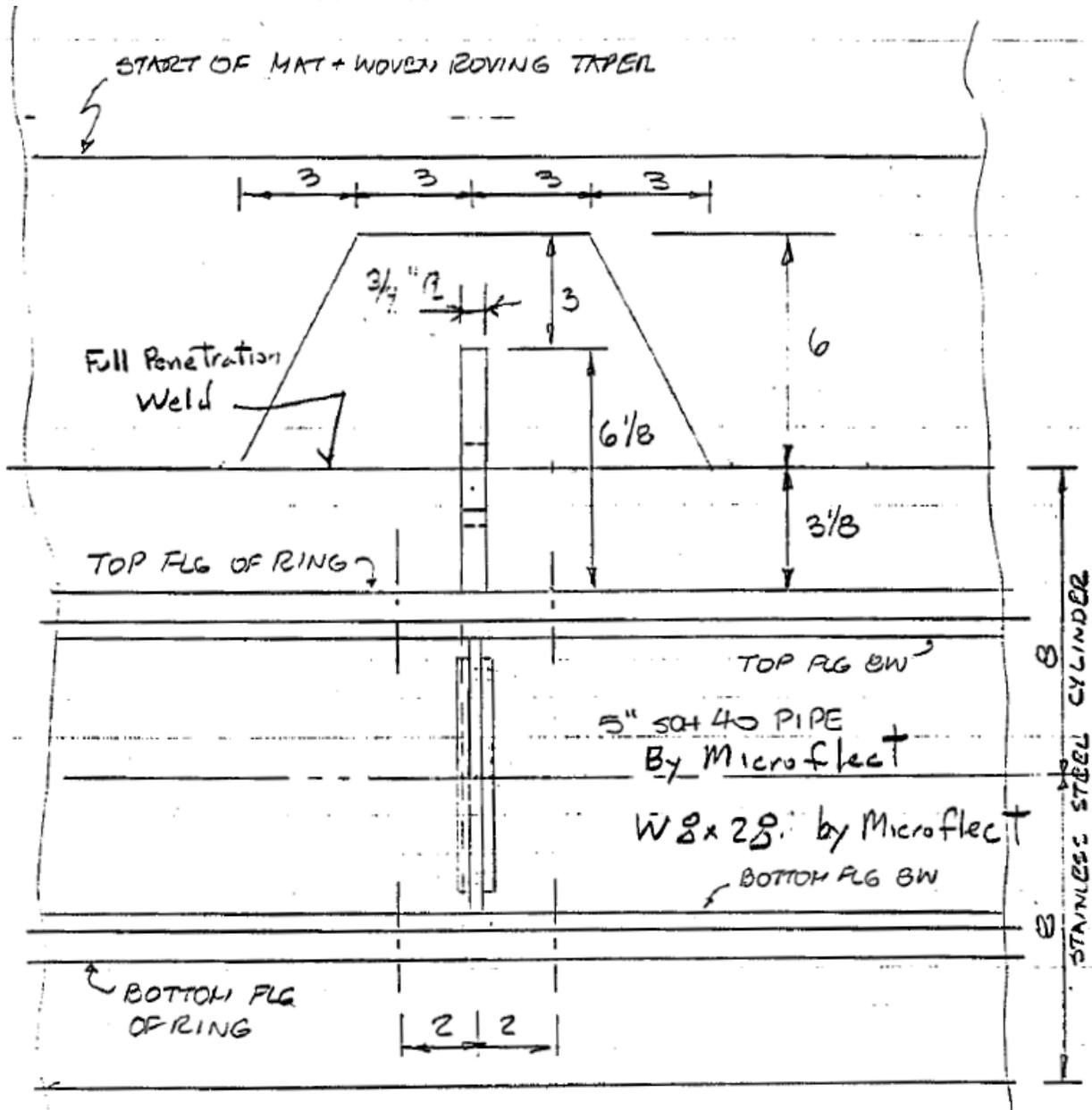


Figure 6.8: Mast Lower Support Plan (View C)

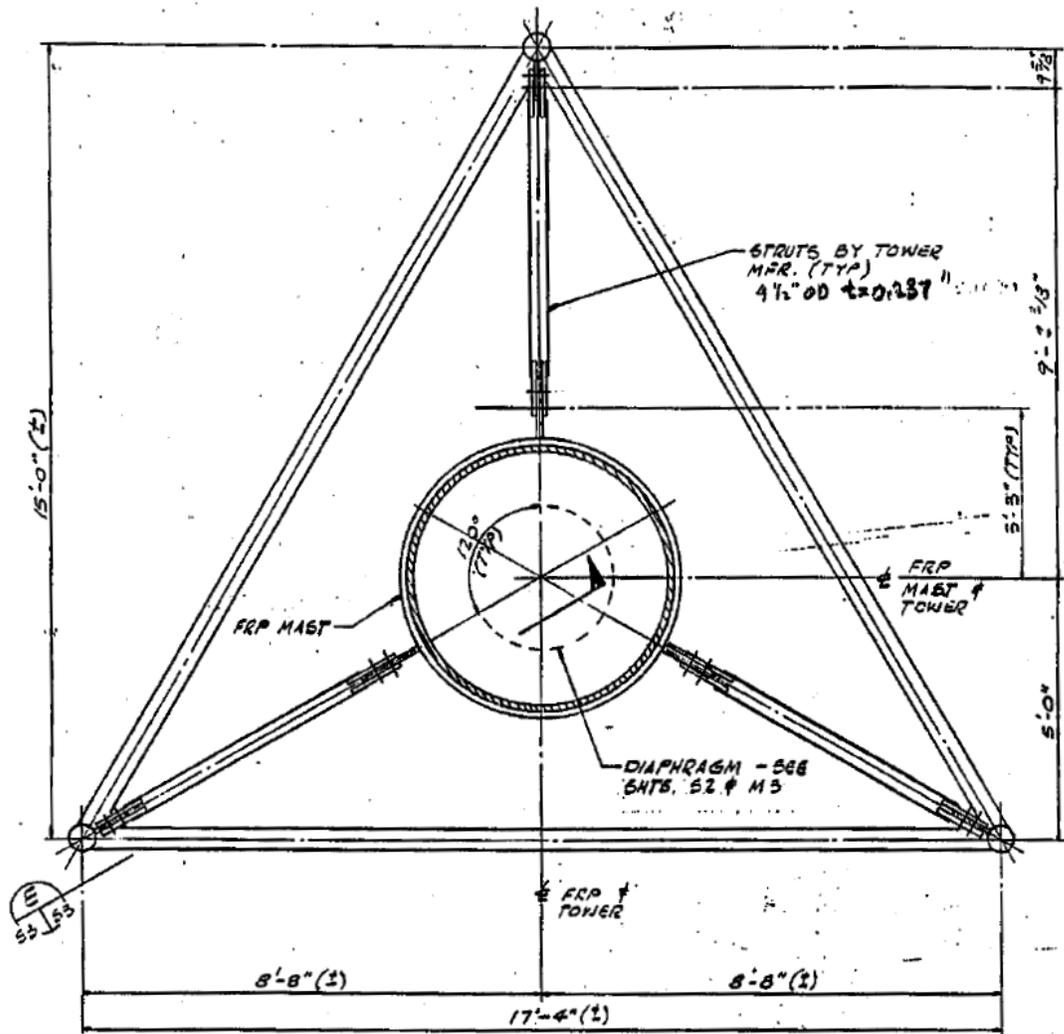
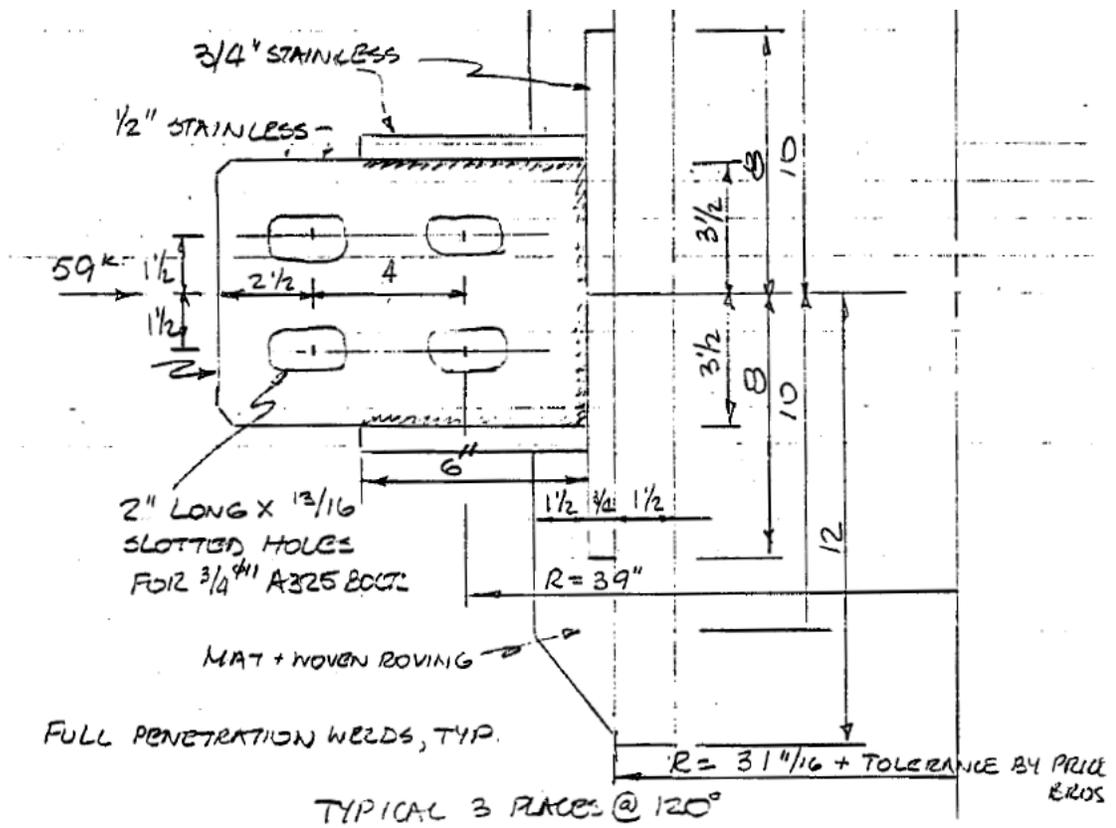


Figure 6.9: Mast Lower Support Connection Detail



Picture 1: Cable Mast Ring



Picture 2: Cable Mast Ring Fasteners Corrosion Damage



Pictures 3: Mast Upper Support Ring.



Pictures 4: Lower Mast Support Ring



