FORM McG. C. C. I. E-3-M 2500

GENERAL COMPUTATION SHEET

McGRAW CONSTRUCTION COMPANY, INC.

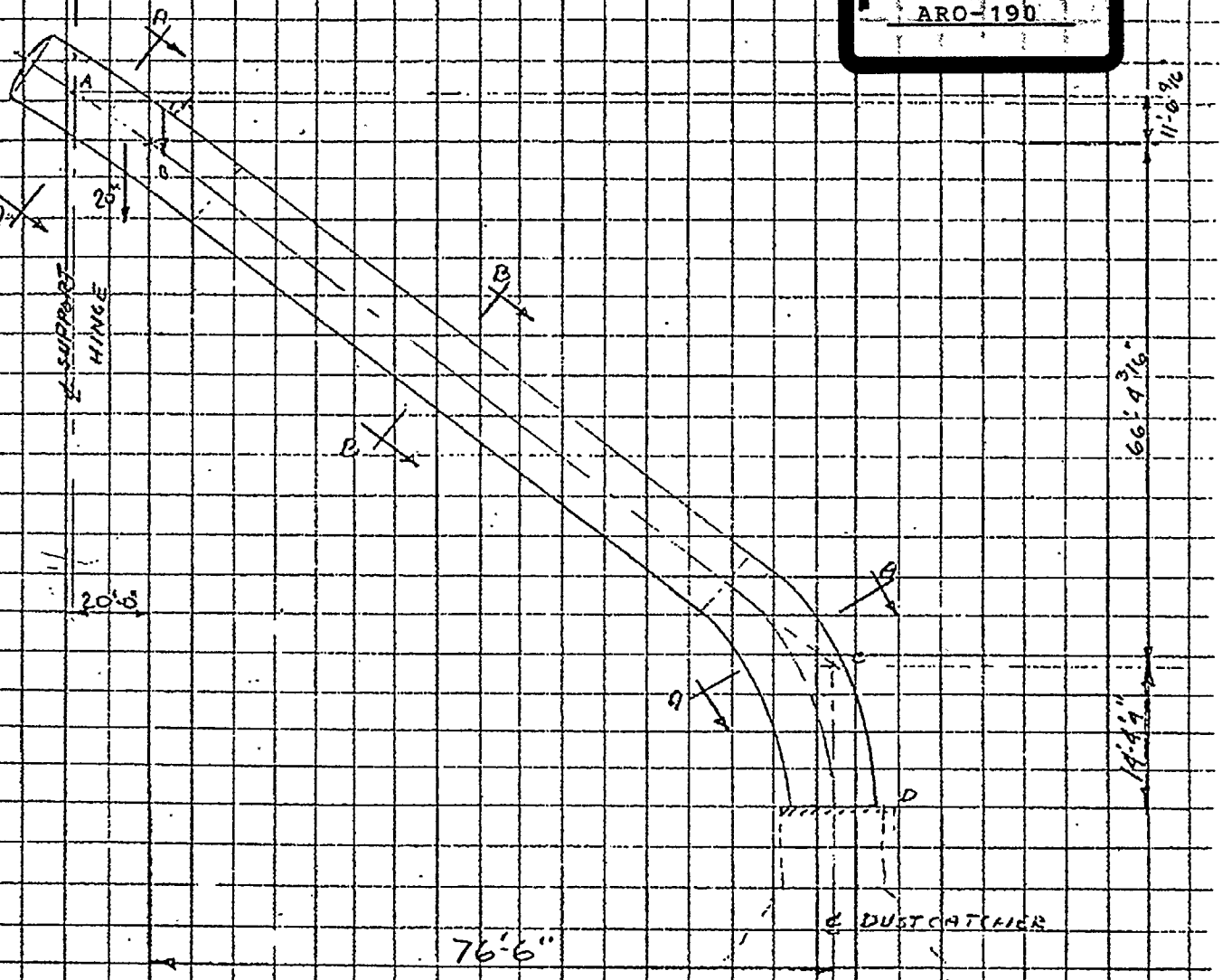
SHEET NO. 1 OF

NAME OF COMPANY ARMCO DATE 10-24-66

COMPUTED BY NORHEIM CHECKED BY JOB #1118 CONT. NO.

PLAINTIFF'S EXHIBIT
ARO-190

BL. FCE. DOWNCOMER ANALYSIS



BLUE

AKE-002486

FORM McG.C. C. I. E-3-M 2500

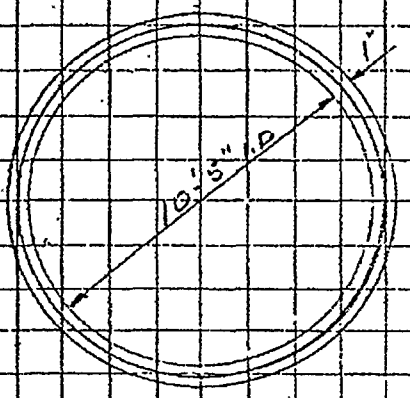
GENERAL COMPUTATION SHEET

McGRAW CONSTRUCTION COMPANY, INC.

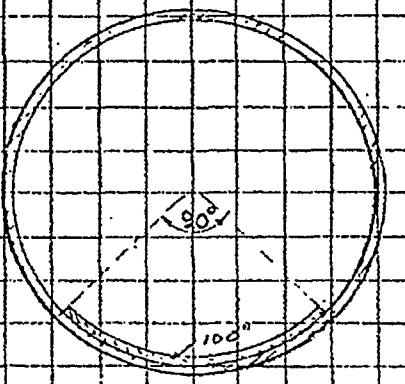
SHEET NO 2 OF

NAME OF COMPANY ARMCO DATE 10-25-66

COMPUTED BY NORHEIM CHECKED BY JOB #1118 CONT. NO.



SECTION A-A.



SECTION B-B

DESIGN LOADS

1a) SECT. A-A WT. PER FT = 10.5 x 3.14 x 40.8 = 1.35 K/FT

b) SECT. B-B WT. PER FT = 10.5 x 3.14 x 20.4 = .678

+ 20.4 x 100/12 = .170

.848 K/FT

2) WIND LOAD ON PROJECTED AREA = .030 x 10.5 = .315 K/FT

3) ALLOWANCE FOR DUST COLLECTING IN DUCT = .1 K/FT

FORM McG.C.C.I. E-3-M 2500

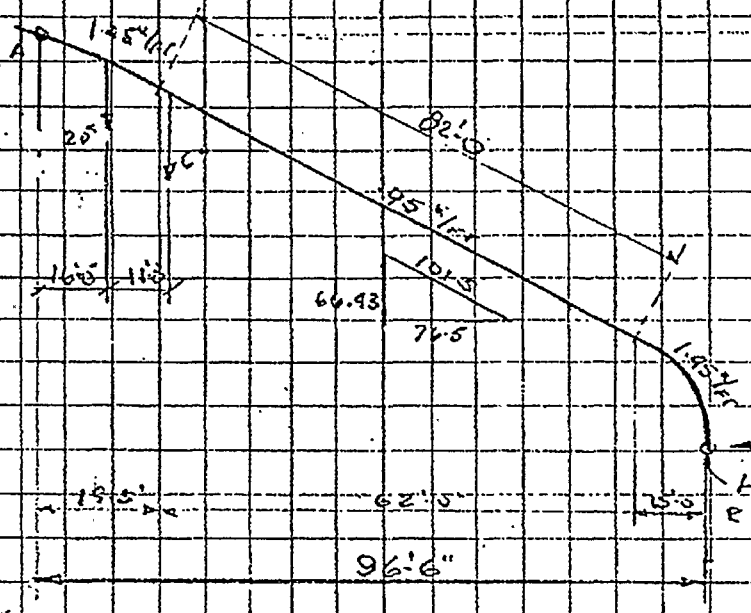
NERAL COMPUTATION SHEET

McGRAW CONSTRUCTION COMPANY, INC.

SHEET NO 3 OF

NAME OF COMPANY ARMCO DATE 10-25-66

COMPUTED BY NORHEIM CHECKED BY JOB # 1118 CONT. NO



$R_B = 1.45 \times \frac{101.5}{76.5} \times 19.5 \frac{86.75}{96.5} + 2.0 \frac{80.5}{96.5} + 6 \frac{69.5}{96.5} + .95 \times 82 \frac{96}{96.5} + \text{NEG.}$

$= 33.6 + 16.7 + 4.3 + 37.$

$= 91.6^{K}$

M_{MAX} @ $Q = 0$ @ x ft

$91.6 = 20 + 6 + 1.45 \frac{101.5}{76.5} \times 19.5 + .95 \frac{101.5}{76.5} x$ (37.4, 1.26x)

$1.26x = 28.2$

$x = 22.4^{FT}$

MOMENT DUE TO DEAD LOAD

$M_{MAX} = 91.6 \times (19.5 + 22.4) - 37.4 - 32.15 - 20 \times 25.9 - 6 \times 14.9 - 1.26 \frac{22.9^2}{2}$

$= 3890 - 1205 - 518 - 90 - 315$

$= 1712^{1-K}$

WIND MOMENT

$M_W = \frac{.315 \times 92.25^2}{8} = 335^{1-K} = 4020^{K-IN}$

BLUE

AKE-002488

FORM McG.C.C.I. E-3-M 2500

GENERAL COMPUTATION SHEET

McGRAW CONSTRUCTION COMPANY, INC.

SHEET NO 4 OF

NAME OF COMPANY ARMCO DATE 10-28-66

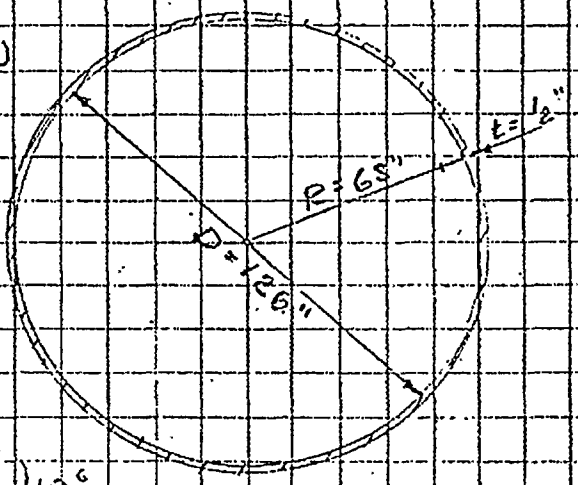
COMPUTED BY NORHEIM CHECKED BY JOB #1118 CONT. NO.

CHECK ON DOWNCOMER

$L = 75' \times 12 = 900$ IN

$r = \frac{I}{A} = \frac{63}{12} = 4.35$ (RADIUS OF GYRATION)

$\frac{L}{r} = \frac{900}{43.5} = 20.7$



APP. MAX. MOMENT ON DOWNCOMER (SH 3)

$= 1712 + 335 = 2047$ '-K

SECTION MOD. $= .098\left(\frac{1.24^4 - 1.23^4}{1.24}\right)10^6$

$= 6060$ IN^3

MAX. STRESS $= \frac{2047 \times 12}{6060} = 4.05$ K/IN^2

BUCKLING OF THE TUBE (REF: JOUR. OF THE STRUCT. DIV. ASCE.) (OCT. 1965)

COLUMN BUCKLING DUE TO BENDING

$\frac{k_1 L}{r} = 20.7 < C_c = \sqrt{\frac{2\pi^2 E}{F_y}} = \sqrt{\frac{2\pi^2 \times 29{,}000{,}000}{36{,}000}} = 126.2$

$\therefore N = \frac{5}{3} + \frac{3\left(\frac{k_1 L}{r}\right)}{8 C_c} - \frac{\left(\frac{k_1 L}{r}\right)^3}{8 C_c^3}$

$= 1.67 + \text{NEG.} = (\text{F.S. BY A.I.S.C.})$

$\therefore f_{all} = \frac{f_y}{N}\left[1 - \frac{f_y}{4\pi^2 E}\left(\frac{k_1 L}{r}\right)^2\right] = \frac{36000}{1.67}\left[1 - \frac{.99 \times 36000}{4\pi^2 \times 29{,}000{,}000} \times 20.7^2\right]$

$= 21.4$ K/IN^2 O.K.

BLUE

AKE-002489

FORM McG.C.C.I. E-3-M 2500

GENERAL COMPUTATION SHEET
McGRAW CONSTRUCTION COMPANY, INC.

SHEET NO 5 OF

NAME OF COMPANY ARMCO DATE 10-28-66

COMPUTED BY NORHEIM CHECKED BY JOB #1118 CONT. NO.

LOCAL BUCKLING DUE TO BENDING

$Z = 0.954 \left(\frac{R}{t}\right)\left(\frac{L}{R}\right)^2 = .954\,(126)\left(\frac{900}{63}\right)^2 = 23800$ (CURVATURE PARAM.)

AISI SPECS LIMITS MAX. $\frac{D}{t} = 3.3\times10^6/F_y = 92 < \frac{D}{t} = 252$

COLUMN RESEARCH COUNCIL (CRC) GIVES

$\left(\frac{L}{r}\right)_{EFF} = 9\sqrt{\frac{126}{.5}} = 143$

AND $\frac{f_{cs}}{F_y} = 1.0$ FOR $\frac{D}{t} = 252 \leq 1.87\sqrt{E/F_y} = 51$

USE (CRC) CURVE TO FIND F_{CR}

$\left(\frac{F_y}{E}\right)\left(\frac{R}{t}\right) = 0.136$ $\therefore \frac{F_{CR}}{F_y} = 0.39$ ∴ (FROM FIG. 4, P 336 Tour. Struct. Div. Vol 91 Oct 65)

$\therefore F_{CR} = 0.39\,F_y = 14\ ^K/_{in^2} \times 1.3 = 18.2\ ^K/_{in^2}$

FROM THIS CAN BE SEEN THAT LOCAL BUCKLING WILL OCCUR BEFORE MAX. ALL BENDING STRESS IN PIPE IS REACHED.

NOW USING A FACTOR OF SAFETY OF 2 AGAINST LOCAL BUCKLING

$F_{ALL} = \frac{18.2}{2} = 9.1\ ^K/_{in^2}$

∴ ADDITIONAL WEIGHT PER FOOT THAT MAY BE ADDED TO PIPE = W

$F_{ALL} = \frac{M}{S}$

$9.1 = \frac{W \cdot 96.5^2 \times 12 + 2047 \times 12}{6060}$

$116.5\,W = 9396 - 2047$

$W = \frac{7349}{116.5} = 2.17\ ^K/_{FT}$ (HORIZONTALLY)

BLUE

AKE-002490

W ALONG PIPE

$W = 2.17 \frac{70.5}{101.5} = 1.64\ ^{\#}/_{FT}$

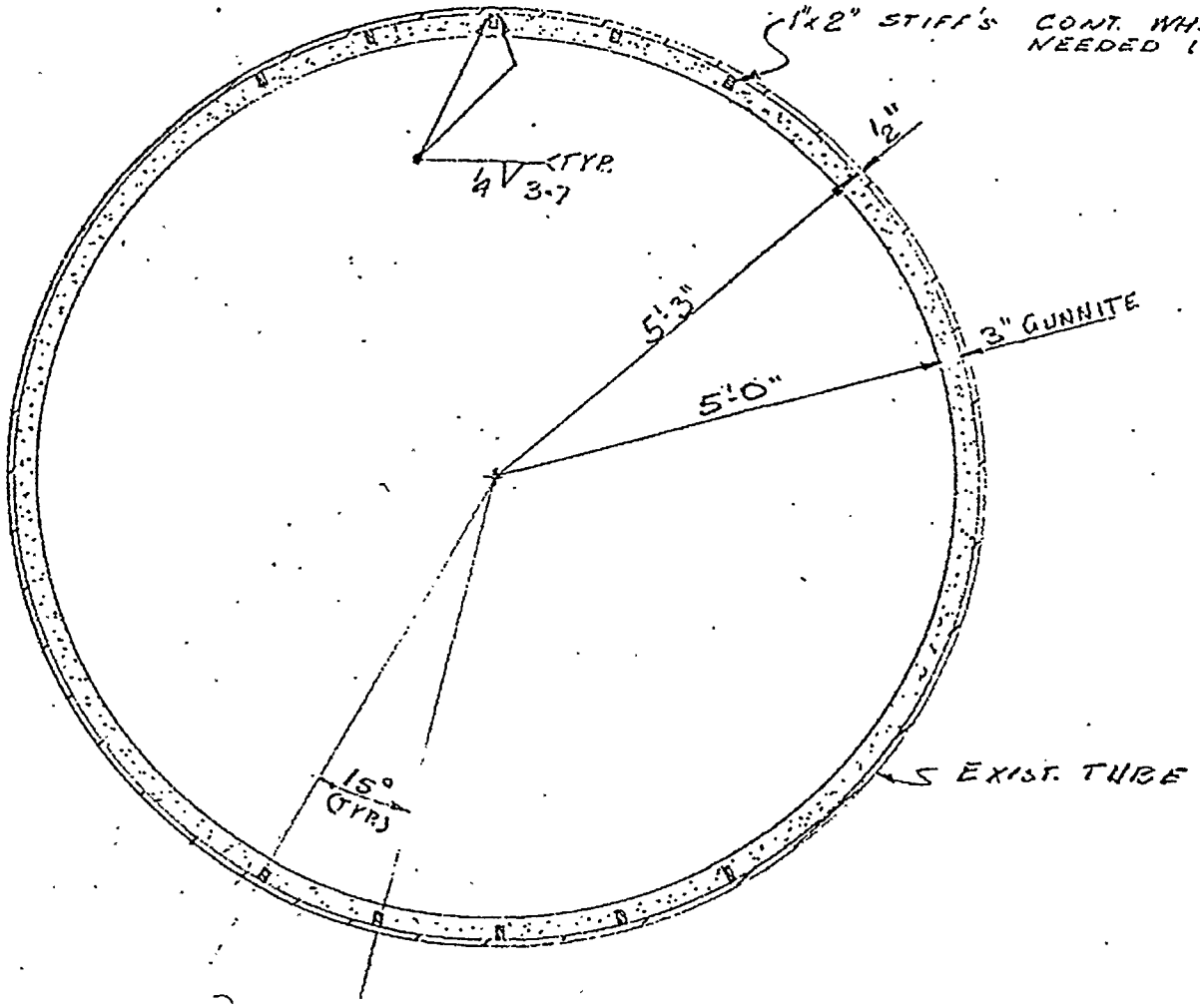
SHEAR & TORSION ASSUMED TO BE NEGLIGIBLE.

CONCLUSION & RECOMMENDATIONS

1) IT WAS IMPOSSIBLE TO RUN AN EXACT ANALYSIS OF THE STATED PROBLEM. DUE TO SEVERAL FACTORS:
   a) CONDITION OF EXISTING DOWNCOMER
   b) UNCERTAIN HOW DETRIMENTAL THE CIRCUMFERENTIAL WELDED JOINTS ARE TO THE TUBE
   c) COMPLEXITY OF PROBLEM. I.E. CERTAIN ASSUMPTIONS HAVE TO BE MADE IN ORDER TO ARRIVE AT FORCES IN THE TUBE.
   d) SHEAR & TORSION ASSUMED NEGLIGIBLE.
   e) TUBE ASSUMED CIRCULAR

IT IS MY OPINION THAT A 3 IN. LAYER OF GUNNITE CAN BE APPLIED TO THE INTERIOR, BUT THE GUNNITE SHOULD BE REINFORCED IN ORDER TO INCREASE THE OVERALL STRENGTH OF THE STRUCTURE. THE DOWNCOMER SHOULD BE WELL INSPECTED, AND ALL WEAK SECTIONS REINFORCED BEFORE ANY LOAD IS PUT ON.

FORM G-5670
Amoco



TYPICAL STIFFENING OF DOWNCOMER

NOTE: ENGINEER TO INSPECT DOWNCOMER AND INSTALL STIFFENERS AT WEAK SECTIONS.

BLUE

AKE-002492