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Design Analysis Report for Compressed Air Piping 241-SY-101 Hydraulic Pump Retrieval Trailer		ECN No. NA

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35 Station 21

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## RELEASE AUTHORIZATION

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~~241-SY-101 Hydraulic Pump Retrieval Trailer~~

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## SUPPORTING DOCUMENT

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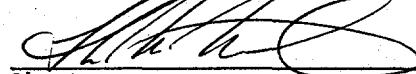
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## 6. Author

Name: Thomas R. Wilson



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## 7. Abstract

12/22/94/12 Dales

The following Design Analysis was prepared by the Westinghouse Hanford Company to determine pressure losses in the compressed air piping installed on the hydraulic trailer for the 241-SY-101 pump retrieval mission.

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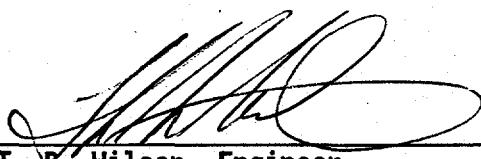
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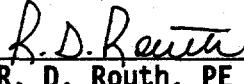
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35 STATION 21

COMPRESSED AIR PIPING  
241-SY-101 HYDRAULIC PUMP RETRIEVAL TRAILER

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DATE: 12/13/94

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DATE: 12/14/94

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DATE: 12/15/94

Westinghouse Hanford Company  
Hanford Operations and Engineering Contractor  
for the  
U.S. Department of Energy

CHECKLIST FOR INDEPENDENT REVIEW

Document Reviewed WHC-SD-WM-DA-183, Rev. 0

Author T. R. Wilson

Yes No NA

- [ ] [ ] Problem completely defined.
- [ ] [ ] Necessary assumptions explicitly stated and supported.
- [ ] [ ]  Computer codes and data files documented.
- [ ] [ ] Data used in calculations explicitly stated in document.
- [ ] [ ] Data checked for consistency with original source information as applicable.
- [ ] [ ] Mathematical derivations checked including dimensional consistency of results.
- [ ] [ ] Models appropriate and used within range of validity or use outside range of established validity justified.
- [ ] [ ]  Hand calculations checked for errors.
- [ ] [ ]  Code run streams correct and consistent with analysis documentation.
- [ ] [ ]  Code output consistent with input and with results reported in analysis documentation.
- [ ] [ ] Acceptability limits on analytical results applicable and supported. Limits checked against sources.
- [ ] [ ] Safety margins consistent with good engineering practices.
- [ ] [ ] Conclusions consistent with analytical results and applicable limits.
- [ ] [ ] Results and conclusions address all points required in the problem statement.

If software analysis performed,

MANDATORY Software QA Log Number N/A

R. D. Reuter  
Reviewer

12/14/94  
Date

## DESIGN VERIFICATION METHOD

The need for design verification has been reviewed with the method selected as indicated below:

x

## Independent Review

### Alternative Calculations

## Qualification Testing

## Formal Design Review

C. E. Hanson *C. E. Hanson*  
**Cognizant/Project/Design Manager**

SD # WHC-SD-WM-DA-183, Rev. 0

ECN #

**DWG(S) #H-2-824510**

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DESIGN ANALYSIS REPORT FOR  
COMPRESSED AIR PIPING, 241-SY-101 HYDRAULIC PUMP RETRIEVAL TRAILER

1.0 INTRODUCTION

The purpose of this analysis is to determine the pressure losses in the compressed air piping installed on the WHC 100-ton Hydraulic Trailer, a component of the 241-SY-101 Equipment Removal System. Compressed air is used to operate the pneumatic vibrators installed on the Hydraulic Trailer and Strongback. To operate effectively, each of the six (6) vibrators must be supplied with compressed air at the same pressure. Regulators are installed at the inlet to each vibrator to control air pressure to the same pressure requirement. The compressed air supply pressure minus the compressed air piping losses must be greater than the regulated pressure requirement at all of the vibrators. This analysis calculates the pressure losses in the longest, hence worst case, piping run only. Pressure losses in shorter piping runs will be less, therefore air pressure at all of the regulators will be adequate if the worst case condition is satisfied.

2.0 SUMMARY OF RESULTS

The pressure losses in the compressed air piping installed on the WHC 100-ton Hydraulic Trailer are small based on the air consumption requirements of the vibrators. Adequate air pressure will be available at all of the regulators if the compressed air supply pressure is greater than approximately 100 psig. Pressure losses will vary with the temperature and humidity of the ambient air, however the compressed air supply pressure noted will more than accommodate these variances.

3.0 DISCUSSION

Each vibrator requires a compressed air flowrate of 93 standard cubic feet per minute, delivered at 80 psig. The compressed air piping is fabricated from nominal 2-inch black steel pipe and fittings. A short piece of hose connects the compressed air piping on the Strongback to the compressed air piping on the Hydraulic Trailer to allow the Strongback to be raised and lowered. The pressure losses through the hose are considered to be negligible. The compressed air piping is routed back to a manifold with a single-point connection for the compressed air supply. Valves are installed to isolate the front, left side, and right side pairs of vibrators. The configuration of the compressed air piping is shown on Drawing H-2-824510. The pressure loss calculations are included in Appendix A.

#### 4.0 REFERENCES

##### DRAWINGS

H-2-824510      Vibrator Air Piping Installation

##### OTHER

Hicks, Tyler G., *Standard Handbook of Engineering Calculations*

WHC-SD-WM-DA-183  
Revision 0

**APPENDIX A - CALCULATIONS**

ANALYTICAL CALCULATIONS

Page \_\_\_\_\_ of \_\_\_\_\_

Subject AIR LINE SIZING : PRESSURE DROPS

Originator S. L. TAYLOR

Date 12/1/94

Checker R. D. ROUTH

Date 12/1/94

SEE ATTACHED MATHCAD CALCULATIONS AND REFERENCES

AIR LINE SIZING - PRESSURE DROPS

BASIS: (2) 2-inch lines down length of trailer from compressor tie-in to rear of strong back.  
upstream pressure is 125 psig from compressor output.  
flow required (each line) = 186 cfm @ 80 psi.  
pipe is 2-inch carbon steel inside diameter is:  $d := 2.067 \text{ in}$

length of each pipe.....  $l := 60 \text{ ft}$   
equivalent length of (2) 90 degree elbows: (pg 3-355). $\theta := 3.5 \text{ ft}$  .....  $E := 2\theta$   
equivalent length of (1) tee: (pg 3-355).....  $t := 12 \text{ ft}$   
total equivalent of pipe: .....  $L := l + E + t$  .....  $L = 79 \text{ ft}$

volume flow rate:  $Q := 186 \text{ scfm}$   
(atmospheric pressure = 14.7)

pressure:  $P := (125 + 14.7)$

volume:  $v := 144$

temperature:  $T := 60 + 460$

gas constant:  $R := 53.33$

compressed air density: (pg 3-390)  $\rho := \frac{P \cdot v}{R \cdot T}$   $\rho = 0.73$

standard air density  $\tau := .075$

weight flow rate: (pg 3-390)  $W := \tau \cdot Q \cdot g$   $W = 837$

velocity: (pg 3-390)  $V := \frac{183.4 \cdot W}{3600 \cdot d^2 \cdot \rho}$   $V = 13.76$

viscosity of air at 80 F is : (pg 3-390)  $\zeta := 0.0186 \text{ cp}$

Reynolds number: (pg 3-390)  $R := \frac{6.32 \cdot W}{d \cdot \zeta}$   $R = 1.38 \cdot 10^5$

on curve 6 (pg 3-389) for 2 inch carbon steel pipe friction factor is:  $\xi := 0.021$

pressure loss in the pipe: (pg 3-391)  $\Delta P := \frac{3.36 \cdot 10^{-6} \cdot \xi \cdot L \cdot W^2}{d^5 \cdot \rho}$   $\Delta P = 0.14 \text{ psi}$

\* all formulas are found in "Standard Handbook of Engineering Calculations", Tyler G.Hicks

### AIR LINE SIZING - PRESSURE DROPS

BASIS: (2) 2-inch lines on each side of strongback from tie-in at rear for rear vibrators at front of strongback.  
upstream pressure is  $(125 - 5.34) = 119.66$  psig from compressor output.  
flow required (each line) = 93 cfm @ 80 psi.  
pipe is 2-inch carbon steel inside diameter is:  $d := 2.067$  in

length of each pipe.....  $l := 30$  ft  
equivalent length of (2) 90 degree elbows: (pg 3-355). $\theta := 3.5$  ft.....  $E := 2\theta$   
equivalent length of (1) 2-inch -1-inch reducer: (pg 3-355).....  $t := 2.0$  ft  
total equivalent of pipe:.....  $L := l + E + t$  .....  $L = 39$  ft

volume flow rate:  $Q := 93$  scfm  
(atmospheric pressure = 14.7)

pressure:  $P := (119.66 + 14.7)$

volume:  $v := 144$

temperature:  $T := 60 + 460$

gas constant:  $R := 53.33$

air density: (pg 3-390)  $\rho := \frac{P \cdot v}{R \cdot T}$   $\rho = 0.7$

standard air density:  $\tau := .075$

weight flow rate: (pg 3-390)  $W := \tau \cdot Q \cdot 60$   $W = 418.5$

velocity: (pg 3-390)  $V := \frac{183.4 \cdot W}{3600 \cdot d^2 \cdot \rho}$   $V = 7.15$

viscosity of air at 80 F is : (pg 3-390)  $z := 0.0186$  cp

Reynolds number: (pg 3-390)  $R := \frac{6.32 \cdot W}{d \cdot z}$   $R = 68795.36$

on curve 6 (pg 3-389) for 2 in carbon steel pipe friction factor is:  $\xi := .022$

pressure loss in the pipe: (pg 3-391)  $\Delta P := \frac{3.36 \cdot 10^{-6} \cdot \xi \cdot L \cdot W^2}{d^5 \cdot \rho}$   $\Delta P = 0.02$  psi

\* all formulas are found in "Standard Handbook of Engineering Calculations", Tyler G.Hicks

### AIR LINE SIZING - PRESSURE DROPS

BASIS: inlet to (2) vibrators.

upstream pressure is 125 psig from compressor output.

flow required (each line) = 186 cfm @ 80 psi.

pipe is 2-inch carbon steel inside diameter is:  $d := 2.067 \text{ in}$

length of each pipe.....  $l := 27 \text{ ft}$   
equivalent length of 90 degree elbows: (pg 3-355).....  $E := 3.5 \text{ ft}$   
equivalent length of (1) tee: (pg 3-355).....  $t := 12 \text{ ft}$   
total equivalent of pipe:  $L := l + E + t$  .....  $L = 42.5 \text{ ft}$

volume flow rate:  $Q := 186 \text{ scfm}$

pressure:  $P := (125 + 14.7)$

volume:  $v := 144$

temperature:  $T := 60 + 460$

gas constant:  $R := 53.33$

compressed air density: (pg 3-390)  $\rho := \frac{P \cdot v}{R \cdot T}$   $\rho = 0.73$

standard density  $\tau := .075$

weight flow rate: (pg 3-390)  $W := \tau \cdot Q \cdot g$   $W = 837$

velocity: (pg 3-390)  $V := \frac{183.4 \cdot W}{3600 \cdot d^2 \cdot \rho}$   $V = 13.76$

viscosity of air at 80 F is: (pg 3-390)  $\zeta := 0.0186 \text{ cp}$

Reynolds number: (pg 3-390)  $R := \frac{6.32 \cdot W}{d \cdot \zeta}$   $R = 1.38 \cdot 10^5$

on curve 6 (pg 3-389) for 2 inch carbon steel pipe friction factor is:  $\xi := 0.021$

pressure loss in the pipe: (pg 3-391)  $\Delta P := \frac{3.36 \cdot 10^{-6} \cdot \xi \cdot L \cdot W^2}{d^5 \cdot \rho}$   $\Delta P = 0.08 \text{ psi}$

\* all formulas are found in "Standard Handbook of Engineering Calculations", Tyler G.Hicks

AIR LINE SIZING - PRESSURE DROPS

BASIS: inlet to floor penetration

neglect inlet air line diameter to trailer air line diameter change.

assume ball valve has the same equivalent length of pipe as a globe valve.

flow required (each line) = 186 cfm @ 80 psi.

pipe is 2-inch carbon steel inside diameter is:  $d := 2.067 \text{ in}$

equivalent length of (1) globe valve: (pg 3-355) .....  $gv := 50 \text{ ft}$   
 length of each pipe .....  $l := 71 \text{ ft}$   
 equivalent length of (2) 45 degree elbows: (3-355)  $\phi := 2.5 \text{ ft}$  .....  $E1 := 4 \cdot \phi$   
 equivalent length of (4) 90 degree elbows: (pg 3-355)  $\theta := 3.5 \text{ ft}$  .....  $E2 := 4 \cdot \theta$   
 equivalent length of (1) tee: (pg 3-355) .....  $\omega := 12 \text{ ft}$  .....  $t := 2 \cdot \omega \text{ ft}$   
 total equivalent of pipe: .....  $L := gv + l + E1 + E2 + t$  .....  $L = 169 \text{ ft}$

volume flow rate:

$$Q := 186 \text{ scfm}$$

pressure:  $P := (125 + 14.7)$

atmospheric pressure = 14.7

volume:  $v := 144$

temperature:  $T := 60 + 460$

gas constant:  $R := 53.33$

compressed air density: (pg 3-390)  $\rho := \frac{P \cdot v}{R \cdot T}$  .....  $\rho = 0.7$

standard density  $\tau := .075$

weight flow rate: (pg 3-390)  $W := \tau \cdot Q \cdot 60$  .....  $W = 837$

velocity: (pg 3-390)  $V := \frac{183.4 \cdot W}{3600 \cdot d^2 \cdot \rho}$  .....  $V = 13.76$

viscosity of air at 80 F is : (pg 3-390)  $z := 0.0186 \text{ cp}$

Reynolds number: (pg 3-390)  $R := \frac{6.32 \cdot W}{d \cdot z}$  .....  $R = 1.38 \cdot 10^5$

on curve 6 (pg 3-389) for 2 inch carbon steel pipe friction factor is:  $\xi := 0.021$

pressure loss in the pipe: (pg 3-391)  $\Delta P := \frac{3.36 \cdot 10^{-6} \cdot \xi \cdot L \cdot W^2}{d^5 \cdot \rho}$  .....  $\Delta P = 0.31 \text{ psi}$

\* all formulas are found in "Standard Handbook of Engineering Calculations:", Tyler G. Hicks

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