

METAL *Bellows* CORPORATION

*#N*  
*OKR*  
*1-5-81*

CR 730

DOCUMENTATION OF COMPLIANCE

FOR

MBC PART NO. 78153

TO THE REQUIREMENTS OF

ASME SECTION III NC-3649 AND CODE CASE N-192 & N-188-1

PREPARED FOR

TENNESSEE VALLEY AUTHORITY

KNOXVILLE, TENNESSEE

REFERENCES

MBC JOB NO. 15278

MBC DESIGN REPORT CR 729

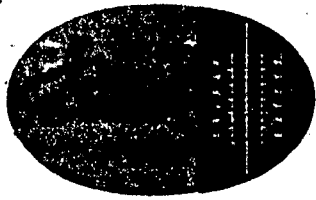
*N4M-526*  
DATE: *OCT 21 1980*  
PROJECT: *BLN CONTRACT 80KA382398*  
DRAWING: *CR 730*  
SHEET: *REV A UNIT 1 & 2*  
USE: *FLEX HOSE ASSEMBLY FOR*  
*INSTR. & CONTROLS*

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Revision A, October 17, 1980

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# Metal Bellows Corporation

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## VERIFICATION OF SPECIFICATION

Title: DOCUMENTATION OF COMPLIANCE FOR METAL BELLOWS CORPORATION PART NO. 78153

Revision: <sup>R7E7A</sup> A 10-17-80

Reference: Tennessee Valley Authority SPECIFICATION NO. BNP-DS-1940-4809-R0  
AND MBC DESIGN REPORT CR 729, REVISION A

Prepared by: *F. Shen* Date: 9/23/80

Checked by: *J. Hoffmann* Date: 9-23-80

Quality Assurance: *G. Kelly* Date: 24 SEPT. 1980

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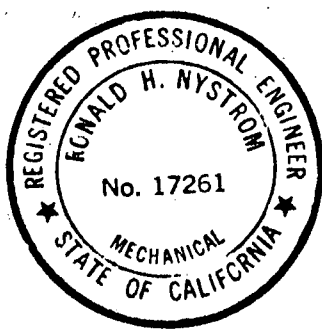
This is to certify that the above document has been reviewed by me, the undersigned, and is correct, complete, and in compliance with the 1977 Edition, including the Winter of 1979 Addenda, of ASME Code, Section III, Paragraph NC-3000 and Code Case N-188-1 and N-192:

Signature: *Ronald H. Nystrom*

Name: Ronald H. Nystrom

Number: 17261

Date: September 24, 1980



INDEX OF REVISIONS

Date and Rev.	Pages Affected			Remarks	Revised By
	Revised	Added	Deleted		
10/17/80 A	Cover, i			Changed to Revision A	<i>R.H. Naylor</i> 10-17-80

SUB-ARTICLE NUMBER	SUB-PARA NO.	ASME SECTION III SUBSECTION ND 3649 REQUIREMENTS	COMPLIANCE BY OWNER NBC	REMARKS /NOTES
3649.2	(A)	PIPING SYSTEM LAYOUT, ANCHORAGE, GUIDING AND MOTIONS	X	1
	(B)	RIGID ANCHORS	X	2
	(C)	INSTALLATION LOCATIONS AND INSPECTION ACCESSIBILITY	X	3
	(D)	SHIPPING BARS	NOT REQD	4
	(H)	FLOW DIRECTION MARKINGS	NOT REQD	5
	(F)	INTERNAL SLEEVES	NOT USED	6
3649.3		ALL PRESSURE BOUNDARY MATERIAL PER ND 2000	X	7
3649.4	(A)	ALLOWABLE CIRCUMFERENTIAL BELLOWS MEMBRANE STRESS	X	8
	(B)	ALLOWABLE MERIDIONAL MEMBRANE AND BENDING STRESS AT 1-1/2 DESIGN PRESSURE FOR NO PERMANENT DEFORMATION	X	9
	(C)	MINIMUM ALLOWED SQUIRM PRESSURE	X	10
	(D)	STRESS MULTIPLICATION FACTOR FOR DESIGN LIFE (KS)(S)(SF)	X	11
	(E)	COMPLIANCE DEMONSTRATED BY (1), (2) OR (3)		
		(1) CALCULATED STRESSES VS STD LIFE VERIFIED BY TESTS	X	12
		(2) INDIVIDUAL TEST TO VERIFY SINGLE DESIGN	NOT APPLICABLE	
		(3) DESIGN ANALYSIS PER ND 3200	NOT APPLICABLE	
	(F)	PROCEDURES USED BY CERTIFICATE HOLDER TO VERIFY DESIGN	X	13
	(G)	TYPES OF SIGNIFICANT STRESSES FOR LIFE CALCULATIONS	X	14
(H)	CERTIFICATE HOLDERS COMPLIANCE REPORT TO ND 3649	X	THIS REPORT	
(I)	CYLINDRICAL BELLOWS COLLARS	X	15	
(J)	EXPANSION JOINT SPRING RATES	X	16	
	CODE CASE NUMBER N-192 USE OF FLEXIBLE HOSE	X	17	

REMARKS/NOTES

1. OWNER WILL COMPLY AND HAS STATED THE EXACT END MOTIONS REQUIRED OF THE HOSE.
2. THE BRAID PROVIDES THE AXIAL RESTRAINT CAUSED BY THE PRESSURE END LOAD, TO MINIMIZE THE NEED FOR RIGID ANCHORS
3. OWNER WILL COMPLY, THE PVIOUS BRAID WILL ALLOW WATER TO LEAK, SEEP, OR FLOW THROUGH IF LEAK DEVELOPS IN HOSE.
4. EXTRA SHIPPING BARS ARE NOT REQUIRED TO MAINTAIN PROPER FACE-TO-FACE LENGTH BECAUSE THE HOSE BRAID PROVIDES REQUIRED RESTRAINT.  
  
THE OWNER MUST COMPLY WITH ALIGNMENT INSTALLATION REQUIREMENTS.
5. FLOW DIRECTION NOT REQUIRED FOR A HOSE.
6. NOT REQUIRED, FLOW VELOCITIES ARE BELOW CRITICAL LEVELS NOTED IN STRESS REPORT CR 729
7. ALL PRESSURE BOUNDARY MATERIAL SHALL CONFORM TO ND2000. THE BRAID MATERIAL SHALL MEET THE REQUIREMENTS OF ASTM-A-580, AND MATERIAL PHYSICAL PROPERTIES SHALL MEET THE REQUIREMENTS OF SECTION III TABLE I-7-2, PLATE MATERIAL.
8. THE STRESS ANALYSIS IS PERFORMED ON THE BELLOWS ONLY AND IGNORES THE COMPRESSIVE HOOP SUPPORT PROVIDED BY THE BRAID.

CALCULATED HOOP STRESS PER CR 729 IS 1.13 KSI  
CODE ALLOWABLE STRESS IS 27.50 KSI FOR 625 CRE2 AT 150 F

REQUIREMENT IS MET.

9. THE CALCULATED BENDING STRESS IS 2.81 KSI BENDING, PLUS 0.56 KSI MERIDIONAL, OR 3.37 KSI TOTAL BENDING STRESS AT OPERATING, TIMES 1.5 = 5.05 KSI PROOF PRESSURE STRESS. ALLOWABLE BENDING STRESS =  $1.5 \times 120 = 180$  KSI FOR 2% CHANGE. DESIGN IS ADEQUATE FOR 7% CHANGE PERMITTED BY THE CODE.

- 10 THE BRAID PROVIDES THE EXTERNAL RESTRAINT TO THE HOSE BELLOWS AND REMAINS ON AT ALL TIMES.

NOTE: EXTERNAL RESTRAINT IS PERMITTED FOR SQUIRM TESTS PER LAST SENTENCE OF PARAGRAPH.

THE HOOP EXTERNAL RESTRAINT FORCE FAR EXCEEDS THE LOW OFFSET LOADS CAUSED BY THE HOSE SQUIRMING.

IN BURST TESTS TO FAILURE (4 TIMES MIN OPERATING PRESSURE), THE HOSE DOES NOT SQUIRM AT ANY TIME, EVEN THOUGH THE BELLOWS DEFORMS DRASTICALLY WITHIN THE BRAID. IN SEVERAL TESTS (AFTER FAILURE) THE BELLOWS HOSE APPEARED TO LOOK LIKE A TUBE INSIDE THE BRAID WITH INTERNAL STIFFENING RINGS. THE OUTSIDE RADIUS OF THE BELLOWS INCREASES TO LOOK LIKE A TUBE WHILE THE INSIDE BELLOWS RADIUS BECOMES VERY SMALL. THIS BURST TEST TO FOUR TIMES MINIMUM OPERATING EXCEEDS THE 2.25 TIMES SQUIRM REQUIREMENT BY THIS PARAGRAPH.

THE HOSE FITCH DOES NOT CHANGE BECAUSE OF THE FRICTION LOAD CAUSED BY THE HOOP SQUEEZE OF THE BRAID

(1) HOSES ARE NORMALLY HELD ONLY AT ONE END BY THE EQUIPMENT WHICH APPLIES THE TEST PRESSURE. THE OPPOSITE END IS ALLOWED TO MOVE AS REQUIRED TO FIT PRESSURE TEST TANK.

(2) PROOF TEST PRESSURE WAS INCREASED TO ACCOUNT FOR DESIGN TEMPERATURES.

- 11 (KS)(S)(SF)

SF = 320 KSI FOR 5000 CYCLES

KS = (KCS)(KSS)

KSC =  $2SC / (SC + SH) = 1.008$

KSS =  $1.470 - (.044)(\text{NUMBER OF TESTS})$

KSS =  $1.470 - (.044)(25)$

(ACTUALLY MBC HAS MORE THAN 25 TESTS PERFORMED TO REAFFIRM S-N CURVE)

KSS = 0.37

KS =  $(1.008)(.37) = .37$

KS = USE 1.25 (MIN CODE ALLOWABLE)

S = 159.10 KSI (SEE CR 729 PARA 2.8)

$(1.25)(159.10)$  KSI < 320KSI  
198.88 KSI < 320 KSI

REQUIREMENT IS MET.

12 MBC IS USING THE STANDARD PUBLISHED AND MODIFIED BY TEST EQUATIONS OF EJMA TO DEMONSTRATE COMPLIANCE WITH THIS LIFE REQUIREMENT. MBC STRESS REPORT, CR729 PROVIDES THE CALCULATIONS TO SHOW LIFE IS MET.

MBC HAS CONDUCTED MANY TESTS OF ITS OWN AND HAS FOUND RESULTS TO BE VERY SIMILAR TO EJMA RESULTS.

13 SEE DESIGN STRESS REPORT CR729 USED FOR DESIGN VERIFICATION. SEISMIC TEST REPORTS CR 364, CR427, CR439 & CR725 ARE AVAILABLE FOR TEST VERIFICATION.

14 ALL TYPES OF STRESS CYCLES WERE CONSIDERED WITH PRESSURE STRESS AND MOTION STRESS OCCURRING SIMULTANEOUSLY TO PRODUCE THE SIGNIFICANT STRESS FOR LIFE CALCULATIONS.

CUMULATIVE STRESSES FOR SEISMIC AND THERMAL MOTION MEET ASME B & PV CODE REQUIREMENT PERND 3649.4(G) AS FOLLOWS

TYPE

T1 = 5000 THERMAL LIFE CYCLES  
T2 = 100 SEISMIC LIFE CYCLES

CYCLES STRESS PER CR 729 PARA 2.8

STT = 159.10 KSI (THERMAL)  
STS = 158.10 KSI (SEISMIC)

CALCULATED CYCLIC LIFE PER CR 729 PARA 2.9

N1 = 24125 CYCLES (THERMAL)  
N2 = 24930 CYCLES (SEISMIC)

USAGE FACTORS

U1 = T1/N1 = .2072538  
U2 = T2/N2 = .0040111

CUMULATIVE USAGE FACTORS SHALL NOT EXCEED 1.0

U1 + U2 + ETC < 1.0  
.207254 + .004011 < 1.0  
.211265 < 1.0

REQUIREMENT IS MET.

- 15 CYLINDRICAL COLLARS ARE USED AND ARE ACCOUNTED FOR, SINCE THE COLLARS PROVIDE AN EXCELLENT LOCATION TO ATTACH THE LIGHT WALL BELLOWS MATERIAL TO HEAVIER RING WHERE THE BRAID AND TUBE STUB ARE ATTACHED. ATTACHMENT OF THE HOSE (OR BELLOWS) JOINTS MEETS THE REQUIREMENTS OF THE ASME B & PV CODE SECTION III PARA. ND4800.
- 16 THE SPRING RATE FOR A LONG HOSE IS USUALLY SO LOW THAT IT IS DIFFICULT TO MEASURE WITHOUT THE BRAID BECAUSE OF SQUIRM. CALCULATED SPRING RATES ARE PROVIDED IN CR729. FRICTION FORCES PROVIDE A LARGER PORTION OF THE LOADING THAN SPRING RATE LOADS AND ARE ALSO CONSIDERED, AND A FACTOR IS APPLIED TO SHOW THAT THE IMPOSED LOADS WILL BE LESS THAN THE ALLOWABLE REQUIRED BY THE CUSTOMER.

NO INDIVIDUAL SPRING RATE TESTS WILL BE PERFORMED ON PRODUCTION HOSE.

- 17 (A) REQUIRED NUMBER OF WIRES FOR HOSE - REF. CR729 PARA 2.10.

$$N = F / (SA)(\cos A) = 5 \text{ WIRES}$$

$$\text{ACTUAL CONSTRUCTION} = (24)(7) = 168 \text{ WIRES}$$

REQUIREMENT IS MET.

- (B) ALL OTHER REQUIREMENTS OF THIS CODE CASE HAVE BEEN MET AS NOTED IN OTHER PORTIONS OF THIS CHECK LIST.