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The Strength of Tubes under Uniform External Pressure

By

Wg.Cdr. P. C. Cleaver, O.B.E., D.C.Ae.

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The Strength of Tubes Under Uniform External Pressure

by

Wing Commander P.C. Cleaver, O.B.E., D.C.Ae.

SUMMARY

This report traces the development of theoretical solutions to the problem of determining the strength of tubes subjected to uniform external pressure, and describes an extensive series of tests to check the accuracy of the Sturm solution to this problem and the effects of material properties on collapse pressure. A total of 530 tests were made covering ranges of length:diameter from 14.0 to 0.51 and nominal thickness:diameter from 0.0098 to 0.056.

The mean collapse pressure of the tests designed to check the accuracy of the Sturm solution corrected for eccentricity effects exceeded the mean theoretical collapse pressure by 2.2%, the standard deviation was 7.0%, and the distribution approximately Gaussian. It is concluded that this theory may confidently be used to predict the strength of tubes under uniform external pressure applied to the sides only.

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1 Introduction

The earliest recorded experimental work on the problem of the collapse of tubes under external pressure was undertaken in 1858 by Fairbairn[1], who derived an empirical formula to fit the results of 32 tests on wrought iron tubes. Thirty years later Bryan[2] made a theoretical study of the long tube free from any form of end constraint and derived the fundamental form of the collapse law:-

$$p = KE\left(\frac{t}{D}\right)^3 \tag{1}$$

Attempts[3,4,5] were made to relate this theory with experimental results, but the measured collapse pressures were roughly 30% below the theoretical values. For thicker tubes Carman[4] and Stewart[5] suggested the empirical formula:-

$$p = A\left(\frac{t}{D}\right) + B \tag{2}$$

which Windenburg[6,7,8] continues to recommend for unfired tubes.

The short tube problem was first solved by Southwell[9] in 1913. His solution contains an unknown term which depends on the type of end constraint; in 1925 Cook[10] determined the constraint constant for the case where the ends are simply constrained to remain circular. In a series of papers published shortly after Southwell's original work, Southwell[11,12,13] together with Cook[14] and Carman[15] attempted to correlate the long and short tube solutions by deriving approximate methods for estimating collapse pressure over both ranges.

In 1914 von Mises[16] derived a solution to the short tube problem with simple end constraints and subjected to lateral pressure only, which contained no unknown terms. In a later paper[17] published in 1929, this solution was extended to cover the case where lateral and end pressure is applied to the tube. Tokugawa[18] obtained a similar solution to this latter problem at about the same time.

The solutions of Southwell, von Mises and Tokugawa are all, however, extremely laborious to apply, and in 1934, Windenburg and Trilling[19] derived a simplified formula, based on von Mises' work, which was subsequently adopted by the American authorities for the design of unfired vessels subjected to external pressure.

In 1941, Sturm[20] extended the rigorous theoretical solutions by solving the problem for the alternative form of end constraint in which the ends of the tube are constrained to remain both circular and cylindrical, for both forms of pressure loading. His work, which is thus the first complete theoretical treatment of the problem, is presented in the simplified form of equation (1), the values of 'K' being presented graphically for a wide range of length, diameter, and thickness for all combinations of pressure loading and end constraint.

In 1947 Sturm and O'Brien[21] suggested that the theory may be extended to the very short tube range, where failure moves towards the plastic mode, by substituting for Young's Modulus, the tangent modulus of the material at the direct compressive stress induced at collapse. The collapse formula therefore takes the final form:-

$$p = K E_t \left(\frac{t}{D}\right)^3 \qquad (3)$$

The experimental works of Carman[4] and Stewart[5] which were confined to long tubes manufactured by techniques which are now obselete, gave poor agreement with theory. A short series of tests by Cornell[22] indicated however that collapse pressures almost equal to the theoretically predicted values may be attained with long specimens of modern drawn tubes. For the short tube range, published test results gave poor agreement with theory, and in no case were data available from which tangent moduli could be determined.

This report describes a comprehensive experimental investigation which was undertaken to check the validity of Sturm's solution for the simple end constraint and lateral pressure case, and the effects of relevant mechanical properties on collapse pressure.

2 Scope of the Investigation

2.1 Selection of Tubes for the Test Programme

The validity of Sturm's theory was checked by a series of tests on tubes manufactured to British Standard Specification T.45. The range of nominal D/t covered by the tests extended from $D/t = 102$ ($2\frac{1}{4}$" dia. × 24 S.W.G.) down to $D/t = 17.85$ (1" dia. × 17 S.W.G.) as detailed in the following table:-

Tube Size	Nominal D/t
$2\frac{1}{4}$" dia. × 24 S.W.G.	102
$1\frac{3}{4}$" dia. × 22 S.W.G.	62.5
1" dia. × 24 S.W.G.	45.5
1" dia. × 22 S.W.G.	35.7
1" dia. × 20 S.W.G.	27.8
1" dia. × 17 S.W.G.	17.85

The mechanical properties, the effects of which were investigated in the second part of the investigation, were Young's Modulus, and the ratio of the 0.1% proof to ultimate strengths; earlier work[23,24,25] on cylinders subjected to axial compression indicated that the latter might be a factor influencing collapse. Two series of tests on light alloy tubes to Specification D.T.D. 460 and commercial brass gave, with the tests on steel tubes, an overall modulus ratio of about 3:1. The effects of the proof:ultimate strength ratio was investigated by five series of tests which, with the T.45 results, covered the following nominal range of this parameter:-

Tube Specification	Nominal Strength		
	f_1	f_t	$\frac{f_1}{f_t}$
T55	14	35	0.4
T26	10.8	20	0.54
D.T.D. 305	18	30	0.6
T58	37	50	0.74
D.T.D. 102A	28	35	0.8
T45	40	45	0.89

A summary of the alloy specifications of all steel tubes used in the investigation is given in Table I.

2.2 Selection of the Range of $^L/_D$

For the T45 test programme, the range of $^L/_D$ extended from the "infinitely" long down to the very short tube. The works of Cook[10,14] and Carman[15] suggested a length of 14 diameters as the minimum to meet the first condition; practical considerations determined the second. Specimens with a length of 0.23 diameters were tested on the $2\frac{1}{4}$" × 24 S.W.G. tube size; in other cases, the length at which satisfactory results could be obtained increased as the $^D/_t$ ratio decreased. The following is a typical range of $^L/_D$ covered in each series of tests:-

14, 12, 10, 9, 8, 6, 4, 2, 1.5, 1.25, 1.0, 0.75, 0.5

For the investigation of mechanical properties, the test programme was concentrated on the short and very short range; it was considered that variation of the proof:ultimate strength ratio would exert its greatest influence in the transition from the elastic to the plastic mode of failure. The following is a typical range of $^L/_D$ covered in each series of tests

14, 4, 3, 2, 1.5, 1.25, 1.0, 0.8, 0.6, 0.5.

2.3 Preparation and Inspection of Specimens

All specimens were cut from lengths of tube of the appropriate size and specification, as purchased from the manufacturers. Larger diameter specimens were cut by hand, the 1" diameter specimens were cut by machine, due precautions being taken in both cases to prevent distortion and damage to specimens during preparation.

Each specimen was carefully examined for variation of wall thickness and ovality at intervals of two diameters along its length, or at the mid-section for tubes shorter than two diameters in length. Readings of wall thickness were taken at six equi-distant points around the periphery, and ovality was measured by direct readings across the three mutually inclined diameters. Full details of the readings recorded are contained in Appendix I.

2.4 Material Control Tests

Specimens of each original length of tube were subjected to both longitudinal and transverse tensile tests. Longitudinal specimens were machined from a section of the tube as cut, the tube curvature being unaffected. Transverse specimens were machined from a section of tube which had been opened out, and which had possibly therefore been subjected to work hardening. Details of the main strength characteristics for each control specimen are given in Appendix I, together with the identification of pressure test specimens applicable thereto.

Although the failure of the tubes takes place under compressive loading, it was decided that results would be related initially to the tensile properties of the material. These are unlikely to differ to a marked degree from the characteristics exhibited under compressive loading and are more readily available.

2.5 Design of Test Equipment

The test equipment was designed so that the ends of the specimens were simply constrained to remain circular. For the $2\frac{1}{4}$" dia. and $1\frac{3}{4}$" dia. tube sizes, the ends of the specimens were supported on knife edged plugs as shown in Fig.1. For all other tests, the specimens were supported on parallel plugs as shown in Fig.2. The degree of end constraint thus applied may vary from specimen to specimen due to variations of tube size within permitted manufacturing tolerances. The high standards achieved in the manufacture of modern drawn tubing reduce these effects to a minimum and little variation of fit was noted during assembly.

The end plugs were carried on a heavy central shaft, one end of which was drilled to vent the inside of the specimen to atmosphere. Relative movement between the specimen and the end plugs was thus readily absorbed.

The inside of the specimen was sealed by a layer of cellotape over the joints between the specimen and the end plugs, and at higher pressures, this was reinforced by a section of cycle inner tube. Seepage of fluid along the thread between the shaft and end plug was eliminated by fitting a countersunk nut and tightly fitting seal washer as shown in Fig.2.

When ready for test, the entire assembly was placed inside a hydraulic cylinder and suitably vented to atmosphere. A number of these cylinders were available, and in each case the smallest cylinder was used into which the specimen would fit. The volume of oil under pressure and hence the stored energy were thereby reduced to a minimum, and the region of failure localised.

Pressure was applied either by a normal aircraft type hand pump, or by a compressed air operated hydraulic ram. An initial series of tests, the results of which are shown in Fig.3, indicated that the rates of application of pressure obtainable with this equipment did not influence collapse strength.

Photographs of the test installation are shown in Figs.4 and 5 respectively.

2.6 Test Observations

Collapse pressures were read directly from large diameter Bourden gauges which had been specially calibrated. In general, collapse was readily indicated both audibly, and by a sudden fall in pressure. For the longer specimens of $2\frac{1}{4}$" dia. tube however, it could only be detected by raising the pressure very slowly by hand pump, and noting the change in 'feel' which occurred at the moment of collapse. Some difficulty was also encountered in detecting the collapse of very short tubes, where the pressure drop caused by the small volumetric change did not always register clearly on the pressure gauge. In some cases the formation of successive lobes around the periphery of the specimen could be detected audibly; the collapse could thus be localised and related to minor variations of wall thickness in the tube.

Fig.6 shows a representative series of collapsed tubes.

3 Results

3.1 Calculation of Theoretical Collapse Pressures

Theoretical collapse pressures were calculated by the method suggested by Sturm and O'Brien[21]. Tangent moduli were determined mathematically from the 'five-point' formula for numerical differentiation derived by Bickley[26] as outlined in Appendix II. For greater accuracy of analysis, the value of the collapse coefficient 'K' was re-computed for a series of values of $^D/t$ within the range covered by the experimental programme. The values of collapse coefficient thus obtained are presented in tabular form in Table II and graphically in Fig.7.

A master chart for estimating collapse pressure is in Table III; columns 1-6 of this chart are universally applicable to tubes of the range of $^t/D$ covered by this investigation. The values of E_t are determined for the appropriate value of $^f/E_t$ obtained from the load-extension readings taken during each control specimen test. The collapse pressure is determined as the product of the figures in columns 3, 5 and 7, and is applicable to those pressure specimens related to that particular control test. Table III includes the values of E_t and collapse pressure for control specimen B1 of the D.T.D. 460 light alloy tests.

3.2 Correlation of Theoretical Collapse Pressures with Experimental Results

Collapse pressures were calculated, at appropriate steps over the complete range of $^L/D$, for the tangent modulus variation obtained from each control test specimen. The results were then presented graphically as a function of $^t/D$ for given values of $^L/D$; a typical series of curves are shown in Fig.8. Experimental results related to each control specimen were then plotted, the arithmetic mean of the measured wall thicknesses of the specimen being plotted on the abscissa scale. Discrepancies between the theoretical and experimental results were then read directly from these curves. The results of each series of tests are shown in Table IV to XVI inclusive, the difference between the theoretical and experimental results being expressed as a percentage of the former.

4 Discussion of Results

4.1 Factors Influencing Collapse Pressure

The theory as postulated by Sturm predicts the collapse pressure of tubes which are geometrically perfect; practical tubes will vary from this perfect shape within permitted manufacturing tolerances. Such variations may be resolved into:-

(a) Eccentricity of the bore relative to the external surface.

(b) Variations from the true circular shape.

Some account must also be taken of variation along the length of the tube of those mechanical properties which may affect collapse pressure. The influence of these three factors is discussed in the following paragraphs.

4.2 Eccentricity of Bore

The stress distribution in an eccentrically bored tube subjected to both internal and external pressure was determined by Jeffery[27,28]. Correction factors for measured eccentricities were applied to the experimental results by the methods outlined in Appendix III. Since in many cases, tube wall thickness had been measured only to the nearest 0.001", variations of this order and less were ignored from an eccentricity view point.

Eccentricity of bore exerts its greatest effects on thicker and shorter tubes, where collapse occurs at stresses beyond the elastic limit; under these conditions comparatively small increases in stress may produce an appreciable reduction of tangent modulus.

The collapse pattern could in almost every case be related to minor variations of wall thickness of the specimen, thus indicating the predominant effect of this variable.

4.3 Ovality of the Specimen

Theoretical work by Timoshenko[29] is confined to the case in which the initial distortion and the final collapse pattern agree. Measurements recorded in Appendix I indicate however the very complex nature of the initial deviations of any tube; in most cases the axis of the major dimension changes appreciably along its length. The problem is further complicated by the lack of any clearly defined datum with which to compare the strength of otherwise geometrically similar tubes.

The agreement obtained between the experimental results and the Sturm theory suggested that the theoretically predicted collapse pressure could be used as the datum. The ovality of the $2\frac{1}{4}$" dia. and $1\frac{3}{4}$" dia. tubes was therefore plotted as a function of the percentage variation of the measured collapse pressure from the theoretical value, ovality being defined as:-

$$\text{Ovality} = \frac{D_{max} - D_{min}}{D_{nominal}}$$

The results plotted in Fig.10 indicate that within the measured limits, ovality exerts no systematic influence on collapse pressure. A further analysis on all the longest tubes ($L/D = 14$), the results of which are plotted in Fig.11, gave a similar result.

4.4 Variation of Material Properties

Tangent Modulus, the only material property used in the Sturm theory, is notably inconsistent, not only between samples of material manufactured to the same specification, but also between different specimens cut from a single large sample. To obtain a measure of its variation, a subsidiary series of tests were undertaken on tensile specimens cut from long lengths of tube taken at random from store. Details of the test observations are in Appendix I, and the results are shown graphically in Fig.12. Since f/E_t is a parameter determined solely by the collapse coefficient and the tube geometry, the percentage variation of tangent modulus is a direct measure of the variation of collapse pressure.

4.5 Analysis of Results

A statistical analysis of the results of the tests on T45 tube presented in Table XVII indicated that their mean value exceeded the mean value of the theoretical results by 0.2% with a standard deviation of 7.2%.

Of the three factors which influence collapse pressure, no systematic variation could be found for ovality and variation of tangent modulus. The results corrected for measured eccentricity of bore by the method outlined in Appendix III are shown in Table XIX. These corrected results for T45 gave a mean collapse pressure which exceeded the theoretical mean by 2.2% with a standard deviation of 7.0%. In only one case, the $2\frac{1}{4}$" dia. x 24 S.W.G. series of tests, does the collapse pressure differ from the theoretical mean by more than 3 standard deviations; in this case it was 3.5. This discrepancy is considered to be due to the difficulty, which was noted earlier in the report, in obtaining reliable results with this particular size tube. The T45 distribution curve was lepto-kurtic, the following table showing the main characteristics:-

Range	Normal Gaussion Distribution	T.45 Distribution
$\pm\sigma$	31%	23.4%
$\pm1.96\ \sigma$	5%	3.09%
$\pm3.09\ \sigma$	0.2%	1%

The results of smaller numbers of tests on T55, T26, D.T.D. 102A and D.T.D. 460 showed that their mean collapse pressures differ from the theoretical mean by less than 3% with standard deviations from 5% to 12%. The results of tests on T58 gave a mean value 7% higher than the theoretical mean with a standard deviation of 10%; although the difference in the mean is higher than for the other materials mentioned above, it is less than three standard deviations of the mean and is therefore statistically acceptable. Two other materials D.T.D. 305 and commercial brass have mean values which differ from the theoretical mean by 18% and 20% respectively and in these cases the theory definitely does not hold. These discrepancies may be due either to gross experimental error or to wide variation of mechanical properties from those recorded during the control tests. It is not thought that these discrepancies invalidate the Sturm theory which gives acceptably close prediction in all other cases.

An examination of Fig.12 shows that a large variation in mechanical properties may be expected along any given length of tube and this could well be sufficient to account for the whole of the scatter in the results obtained except for the cases of D.T.D. 305 and commercial brass.

5 Conclusions

The results of the first part of the experimental programme which was undertaken on T45 tubes indicates that the mathematical theory developed by R.G. Sturm at the University of Illinois, predicts the collapse pressure of modern drawn steel tubes to a high degree of accuracy for the condition where pressure is applied to the sides of the tube, and the tube ends are simply constrained to remain circular. The theory is applicable to tubes of all lengths, for both the elastic and plastic modes of failure, collapse pressure being determined from the formula:-

$$p = K E_t \left(\frac{t}{D}\right)^3 \qquad (3)$$

where K is a coefficient determined by the dimensions of the specimen,

E_t is the value of the longitudinal tensile tangent modulus at the direct compressive stress induced at collapse.

The result of the second part of the experimental programme* indicates that, in general, variations of the ratio of proof to ultimate strength are insignificant, and confirm that the tangent modulus is the only mechanical property which exerts any influence on collapse pressure. Accurate information on the variation of this parameter under longitudinal tensile loading permits equation (3) to be applied with complete confidence. For practical applications however, the use of a composite "least value" curve as suggested by Sturm and O'Brien[21] is probably desirable.

Eccentricity of the bore relative to the exterior surface of the tube is the predominant manufacturing variable affecting collapse strength, but for eccentricities within the limits imposed by current specifications, its effects are small, and for practical purposes, may be neglected.

Variations in the circularity of the tube exert no measurable systematic influence on collapse strength, and provided such variations are within the limits imposed by current tube specifications, this may also be neglected.

REFERENCES

No.	Author	Title, etc.
1	Fairbairn, W.	Resistance of tubes to collapse Philosophical Transactions 1858, p.389 British Association Report 1857, p.215
2	Bryan, G.H.	Application of Energy Test to Collapse of Long Thin Pipe under External Pressure Proc. Cambridge Philosophical Society, Vol.6, p.287, 1888
3	Carman, A.P.	Resistance of Tubes to Collapse Physical Review, Vol.21, December, 1905, pp.381-387 Scientific Abstracts, 1906, No.239
4	Carman, A.P. and Carr, M.L.	Resistance of Tubes to Collapse University of Illinois Bulletin, Vol.3, No.17 June, 1906 Scientific Abstracts 1906, No.1986
5	Stewart, R.T.	Collapse Pressures of Bessemer Steel Lap-Welded Tubes 3" to 10" in diameter Transactions of American Society of Mechanical Engineers, Vol.27, pp.730-822, 1906

No.	Author	Title, etc.
6	Windenburg, D.F.	Master Charts for the Design of Pressure Vessels under External Pressure Transactions of the American Society of Mechanical Engineers, Vol.69, pp.345-351, 1947
7	Windenburg, D.F.	Vessels under External Pressure Mechanical Engineering, Vol. 59 pp.601-608 August, 1937
8	-	A.P.I./A.S.M.E. Code for the Design, Construction, Inspection and Repair of Unfired Pressure Vessels for Petroleum Liquid and Gases 1951
9	Southwell, R.V.	On the General Theory of Elastic Stability Philosophical Transactions, Series A, Vol.213, pp.187-244, 1913
10	Cook, G.	The Collapse of Short Thin Tubes by External Pressure Philosophical Magazine, Vol.50, pp.844-848, October, 1925
11	Southwell, R.V.	On the Collapse of Tubes by External Pressure Philosophical Magazine, Vol.25, pp.687-698, May, 1913
12	Southwell, R.V.	On the Collapse of Tubes by External Pressure Philosophical Magazine, Vol.26, pp.502-511, September, 1913
13	Southwell, R.V.	On the Collapse of Tubes by External Pressure Philosophical Magazine, Vol.29, pp.67-77, January, 1915
14	Cook, G.	The Collapse of Short Thin Tubes by External Pressure Philosophical Magazine, Vol.28, pp.51-56, July, 1914
15	Carman, A.P.	The Collapse of Short Thin Tubes University of Illinois Engineering Experimental Station, Bulletin No.99 June, 1917
16	von Mises, R.	Der Kritische Aussendruck Zylindrischer Rohre Zeitung V.D.I., Vol.58, pp.750-755 1914
17	von Mises, R.	Der Kritische Aussendruck für Allseits belastete zylindrische Rohre Fest zum 70 Geburtstag von Prof. Dr. A Stodola, Zurich pp.418-430 1929
18	Tokugawa, T.	Model Experiments on the Elastic Stability of Closed and Cross Stiffened Circular Cylinders under Uniform External Pressure Proceedings of the World Engineering Congress, Tokyo, Vol.29, pp.249-279 1929

REFERENCES (Contd)

No.	Author	Title, etc.
19	Windenburg, D.F. and Trilling, C.	Collapse by Instability of Thin Cylindrical Shells under External Pressure Transactions of the American Society of Mechanical Engineers, Vol.56, Paper A.P.M.-56-20
20	Sturm, R.G.	A Study of the Collapsing Pressure of Thin Walled Cylinders University of Illinois Engineering Experimental Station Bulletin No.329 1941
21	Sturm, R.G. and O'Brien, H.L.	Computing Strength of Vessels Subjected to External Pressure Transactions of the American Society of Mechanical Engineers, Vol.69, pp.353-358 1947
22	Cornell, Sidney	The Collapse of Long Cylindrical Shells under External Pressure Proceedings of the Society for Experimental Stress Analysis, Vol.VI, No.1
23	Bowers, I.G.	Compression Tests on Short Tubes M.A.P. Scientific and Technical Memorandum No.17/44 Flight Refuelling Report
24	Douglas, W.D. and Carmichael, D.	Determination of the Minimum Values of Strength and Stiffness of Various Metals which only just Comply with the Requirements of their Respective Specifications R.A.E. Report M.T.5587
25	Shelley, J.H.	Strength Data on Circular Metal Cylinders Under Axial Compression R.A.E. Technical Note Structures 122
26	Bickley, W.G.	Formulae for Numerical Differentiation Mathematical Gazette, Vol.25, pp.19-27, 1941
27	Jeffery, G.B.	Plane Stress and Plane Strain in Bi-Polar Co-ordinates Philosophical Transactions of the Royal Society Series A, Vol.221, 1921
28	Jeffery, G.B.	The Stresses in Cylinders and Pipes with Eccentric Bore Report of the British Association for the Advancement of Science, 1921, pp.356-358
29	Timoshenko, S.	Applied Elasticity pp.242-245

APPENDIX I

Details of Specimens and Test Observations

This Appendix contains full details of each pressure test specimen as recorded during the pre-test inspection; of the mechanical properties of the control test specimens applicable thereto, and of the actual test results obtained. It is divided into a number of sub-appendices, each containing the details relating to a complete series of tests on one tube size and specification.

2 Details of Pre-test Inspection

The pre-test inspection provided detailed information of the physical dimensions of each pressure test specimen. Measurements of wall thickness were made at six equi-distant points, A, B, C, ... F, around the periphery at intervals of two diameters (Stations 1, 2, ... 7) along the length of each tube, or at the mid point of tubes shorter than two diameters in length. The ovality was measured by direct readings across the diameters AD, BE and CF, deviations from the truly circular form being recorded in thousandth of an inch variation from the measured mean.

3 Mechanical Properties of Material Control Test Specimens

Control test specimens were cut from each length of tube from which the pressure test specimens were subsequently prepared. Details of the salient mechanical properties are included together with the correlation between mechanical test results and individual pressure test specimens.

Full details of all load-extension readings, from which the variation of tangent modulus was obtained are included as a separate sub-appendix.

4 Details of Test Results

The details of the test results include the collapse pressure corrected for gauge error, effective length and $^L/D$. The number of lobes actually formed in the collapsed tube, and the number of lobes which would have formed had the whole periphery of the tube collapsed are also recorded for each pressure test specimen.

The position of the crest and trough of each lobe is indicated in the wall thickness records, the crest being indicated as a shaded line, and the trough by a rectangle respectively.

The test results are presented graphically as a function of $^L/D$ for each series of tests.

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APPENDIX IA

Variations in Wall Thickness for 2.25" O/D x 24 S.W.G. x T45 Steel Tube Showing Relation Between Thickness and Collapse Pattern - Set I

Tube No.	Station	A	B	C	D	E	F	Mean
1.1	1	0.026	0.027	0.027	0.027	0.027	0.025	0.0265
	2	0.026	0.027	0.027	0.027	0.027	0.026	0.0266
	3	0.026	0.027	0.027	0.027	0.026	0.025	0.0263
	4	0.025	0.026	0.027	0.027	0.026	0.025	0.026
	5	0.026	0.026	0.027	0.027	0.026	0.025	0.0261
	6	0.026	0.026	0.027	0.026	0.026	0.025	0.026
	7	0.026	0.026	0.028	0.027	0.026	0.025	0.0263
	8	0.026	0.026	0.028	0.027	0.026	0.025	0.0263
1.2	1	0.029	0.029	0.029	0.028	0.027	0.027	0.0281
	2	0.029	0.030	0.029	0.028	0.027	0.028	0.0285
	3	0.029	0.030	0.029	0.028	0.027	0.028	0.0285
	4	0.029	0.029	0.028	0.028	0.028	0.028	0.0283
	5	0.029	0.029	0.028	0.027	0.027	0.028	0.028
	6	0.029	0.029	0.028	0.027	0.027	0.029	0.0281
	7	0.029	0.029	0.029	0.028	0.027	0.029	0.0285
1.3	1	0.030	0.030	0.028	0.027	0.027	0.029	0.0285
	2	0.030	0.029	0.028	0.027	0.027	0.028	0.0281
	3	0.029	0.029	0.028	0.027	0.027	0.028	0.028
	4	0.029	0.029	0.028	0.027	0.027	0.028	0.028
	5	0.029	0.029	0.029	0.027	0.028	0.028	0.0283
	6	0.029	0.029	0.028	0.027	0.027	0.028	0.028
	7	0.029	0.030	0.028	0.027	0.028	0.028	0.0283
1.4	1	0.027	0.028	0.029	0.029	0.028	0.028	0.0281
	2	0.026	0.027	0.029	0.029	0.028	0.027	0.0277
	3	0.026	0.027	0.029	0.029	0.028	0.027	0.0277
	4	0.026	0.027	0.029	0.029	0.028	0.027	0.0277
	5	0.027	0.028	0.029	0.029	0.028	0.027	0.028
	6	0.027	0.028	0.029	0.029	0.028	0.027	0.028
1.5	1	0.025	0.024	0.025	0.026	0.027	0.026	0.0255
	2	0.025	0.025	0.025	0.026	0.026	0.026	0.0255
	3	0.025	0.024	0.025	0.026	0.026	0.026	0.0253
	4	0.025	0.025	0.026	0.026	0.026	0.026	0.0257
	5	0.025	0.025	0.026	0.026	0.026	0.026	0.0257

APPENDIX IA (Contd)

Tube No.	Station	A	B	C	D	E	F	Mean
1.6	1	0.025	0.025	0.025	0.026	0.027	0.026	0.0257
	2	0.026	0.025	0.026	0.026	0.027	0.025	0.0258
	3	0.026	0.026	0.026	0.025	0.026	0.026	0.0258
	4	0.026	0.026	0.026	0.026	0.026	0.026	0.026
	5	0.026	0.026	0.025	0.026	0.026	0.026	0.0258
1.7	1	0.028	0.027	0.028	0.029	0.029	0.028	0.0281
	2	0.028	0.028	0.028	0.029	0.029	0.029	0.0285
	3	0.028	0.027	0.027	0.028	0.029	0.029	0.028
	4	0.028	0.027	0.027	0.029	0.029	0.029	0.0281
1.8	1	0.025	0.026	0.026	0.027	0.026	0.025	0.0258
	2	0.026	0.027	0.027	0.026	0.025	0.025	0.026
	3	0.025	0.026	0.026	0.026	0.025	0.025	0.0255
1.9	1	0.026	0.027	0.026	0.026	0.026	0.025	0.026
	2	0.026	0.026	0.025	0.025	0.026	0.026	0.0257
1.10	1	0.025	0.026	0.026	0.026	0.026	0.026	0.0258
1.11	1	0.028	0.027	0.027	0.028	0.029	0.029	0.028
1.12	1	0.025	0.026	0.026	0.025	0.025	0.025	0.0253
1.13	1	0.027	0.027	0.028	0.029	0.029	0.028	0.028
1.14	1	0.026	0.026	0.025	0.025	0.025	0.026	0.0255
1.15	1	0.026	0.025	0.025	0.025	0.025	0.026	0.0253
1.16	1	0.026	0.026	0.027	0.028	0.029	0.028	0.0273
1.17	1	0.027	0.027	0.027	0.028	0.028	0.028	0.0275
1.18	1	0.028	0.028	0.028	0.028	0.027	0.027	0.0277
1.19	1	0.027	0.027	0.027	0.027	0.028	0.028	0.0273
1.20	1	0.028	0.028	0.028	0.028	0.028	0.027	0.0278
1.21	1	0.027	0.028	0.028	0.027	0.027	0.027	0.0273

APPENDIX IA (Contd)

Variations of Wall Thickness for 2.25" O/D x 24 S.W.G. x T45 Steel Tubes Showing Relation Between Wall Thickness and Collapse Pattern - Set II

Tube No.	Station	A	B	C	D	E	F	Mean
2.1	1	0.027	0.028	0.028	0.027	0.026	0.026	0.027
	2	0.026	0.028	0.028	0.027	0.026	0.026	0.0268
	3	0.026	0.027	0.028	0.027	0.026	0.025	0.0265
	4	0.025	0.027	0.028	0.028	0.027	0.025	0.0266
	5	0.025	0.027	0.028	0.028	0.026	0.025	0.0265
	6	0.027	0.025	0.028	0.027	0.025	0.025	0.0261
	7	0.026	0.028	0.029	0.028	0.026	0.025	0.027
	8	0.025	0.028	0.029	0.028	0.027	0.025	0.027
2.2	1	0.025	0.025	0.025	0.024	0.024	0.025	0.0247
	2	0.025	0.025	0.024	0.024	0.024	0.025	0.0245
	3	0.025	0.025	0.025	0.024	0.024	0.025	0.0247
	4	0.025	0.024	0.024	0.023	0.024	0.025	0.0241
	5	0.025	0.025	0.024	0.024	0.025	0.025	0.0247
	6	0.025	0.025	0.024	0.024	0.025	0.025	0.0247
	7	0.025	0.025	0.025	0.024	0.025	0.025	0.0248
2.3	1	0.027	0.028	0.028	0.028	0.027	0.026	0.0273
	2	0.027	0.028	0.029	0.028	0.027	0.026	0.0275
	3	0.026	0.028	0.028	0.028	0.027	0.026	0.0271
	4	0.026	0.028	0.028	0.028	0.027	0.026	0.0271
	5	0.027	0.028	0.029	0.028	0.027	0.026	0.0275
	6	0.027	0.028	0.028	0.028	0.027	0.026	0.0273
	7	0.027	0.028	0.029	0.027	0.027	0.026	0.0273
2.4	1	0.025	0.025	0.027	0.024	0.024	0.024	0.0248
	2	0.025	0.025	0.027	0.027	0.025	0.025	0.0257
	3	0.025	0.026	0.026	0.026	0.024	0.024	0.0251
	4	0.025	0.026	0.025	0.025	0.024	0.024	0.0248
	5	0.024	0.024	0.025	0.025	0.024	0.024	0.0243
	6	0.026	0.028	0.027	0.025	0.027	0.026	0.0265
2.5	1	0.030	0.029	0.026	0.027	0.029	0.029	0.0283
	2	0.029	0.028	0.027	0.027	0.028	0.029	0.028
	3	0.029	0.027	0.027	0.026	0.027	0.029	0.0275
	4	0.030	0.028	0.028	0.027	0.028	0.028	0.0281
	5	0.028	0.029	0.029	0.029	0.029	0.029	0.0289

APPENDIX IA (Contd)

Type No.	Station	A	B	C	D	E	F	Mean
2.6	1	0.026	0.027	0.027	0.028	0.029	0.029	0.0277
	2	0.028	0.028	0.027	0.027	0.029	0.029	0.028
	3	0.027	0.027	0.026	0.027	0.028	0.028	0.0271
	4	0.028	0.027	0.026	0.027	0.028	0.029	0.0275
	5	0.028	0.027	0.026	0.027	0.029	0.029	0.0277
2.7	1	0.028	0.027	0.027	0.027	0.028	0.028	0.0275
	2	0.028	0.028	0.027	0.028	0.028	0.028	0.0278
	3	0.028	0.028	0.028	0.028	0.028	0.028	0.028
	4	0.028	0.027	0.027	0.028	0.028	0.028	0.0277
2.8	1	0.025	0.025	0.025	0.025	0.025	0.025	0.025
	2	0.024	0.024	0.025	0.026	0.025	0.024	0.0247
	3	0.025	0.025	0.025	0.025	0.025	0.024	0.0248
2.9	1	0.029	0.028	0.028	0.026	0.027	0.028	0.0277
	2	0.029	0.028	0.027	0.027	0.028	0.029	0.028
2.10	1	0.028	0.028	0.027	0.027	0.027	0.028	0.0275
2.11	1	0.025	0.026	0.025	0.025	0.025	0.025	0.0251
2.12	1	0.025	0.025	0.025	0.025	0.025	0.025	0.025
2.13	1	0.025	0.025	0.025	0.025	0.025	0.025	0.025
2.14	1	0.025	0.024	0.024	0.025	0.025	0.025	0.0247
2.15	1	0.024	0.025	0.025	0.025	0.025	0.024	0.0247
2.16	1	0.024	0.025	0.025	0.025	0.025	0.025	0.0248
2.17	1	0.025	0.024	0.024	0.025	0.025	0.025	0.0247
2.18	1	0.024	0.024	0.024	0.025	0.025	0.025	0.0245
2.19	1	0.024	0.024	0.024	0.025	0.025	0.025	0.0245
2.20	1	0.024	0.024	0.025	0.025	0.024	0.024	0.0243
2.21	1	0.024	0.024	0.025	0.025	0.024	0.024	0.0243

APPENDIX IA (Contd)

Variations from Truly Circular Form of 2.25" Dia. x 24 S.W.G. x T45 Steel Tube - Set I

Tube No.	Station	Maximum	Position	Minimum	Position
1.1	1	+0.017	F - C	-0.017	E - B
	2	+0.013	A - D	-0.013	E - B
	3	+0.011	A - D	-0.011	E - B
	4	+0.003	F - C	-0.003	E - B
	5	+0.008	A - D	-0.008	E - B
	6	+0.007	A - D	-0.007	E - B
	7	+0.002	F - C	-0.002	E - B
	8	+0.018	F - C	-0.018	A - D
1.2	1	+0.013	B - E	-0.013	A - D
	2	+0.007	F - C	-0.007	B - E
	3	+0.010	F - C	-0.010	B - E
	4	+0.002	F - C	-0.002	B - E
	5	+0.004	F - C	-0.004	B - E
	6	+0.002	F - C	-0.002	A - D
	7	+0.030	B - E	-0.030	A - D
1.3	1	+0.012	B - E	-0.012	A - D
	2	+0.005	F - C	-0.005	A - D
	3	+0.005	F - C	-0.005	A - D
	4	+0.003	F - C	-0.003	E - B
	5	+0.002	F - C	-0.002	E - B
	6	+0.003	F - C	-0.003	A - D
	7	+0.012	F - C	-0.012	A - D
1.4	1	+0.006	B - E	-0.006	A - D
	2	+0.015	F - C	-0.015	A - D
	3	+0.007	F - C	-0.007	A - D
	4	+0.001	A - D	-0.001	F - C
	5	+0.005	A - D	-0.005	F - C
	6	+0.021	A - D	-0.021	E - B
1.5	1	+0.016	B - E	-0.016	F - C
	2	+0.020	B - E	-0.020	F - C
	3	+0.014	B - E	-0.014	F - C
	4	+0.006	F - C	-0.006	E - B
	5	+0.030	F - C	-0.030	E - B

APPENDIX IA (Contd)

Tube No.	Station	Maximum	Position	Minimum	Position
1.6	1	+0.009	F - C	-0.009	A - D
	2	+0.008	E - B	-0.008	A - D
	3	+0.007	E - B	-0.007	A - D
	4	+0.006	E - B	-0.006	A - D
	5	+0.014	F - C	-0.014	A - D
1.7	1	+0.004	F - C	-0.004	E - B
	2	+0.003	A - D	-0.003	E - B
	3	+0.003	A - D	-0.003	E - B
	4	+0.007	F - C	-0.007	E - B
1.8	1	+0.003	F - C	-0.003	A - D
	2	+0.005	A - D	-0.005	E - B
	3	+0.010	A - D	-0.010	E - B
1.9	1	+0.005	F - C	-0.005	E - B
	2	+0.003	A - D	-0.003	F - C
1.10	1	+0.025	A - D	-0.025	F - C
1.11	1	+0.020	E - B	-0.020	F - C
1.12	1	+0.004	E - B	-0.004	A - D
1.13	1	+0.004	A - D	-0.004	E - B
1.14	1	+0.014	A - D	-0.014	F - C
1.15	1	+0.004	F - C	-0.004	E - B
1.16	1	+0.009	B - E	-0.009	F - C
1.17	1	+0.001	B - E	-0.001	F - C
1.18	1	+0.003	F - C	-0.003	A - D
1.19	1	+0.005	E - B	-0.005	F - C
1.20	1	+0.005	F - C	-0.005	B - E
1.21	1	+0.004	A - D	-0.004	F - C

APPENDIX IA (Contd)

Variations from Truly Circular Form of 2.25" Dia. x 24 S.W.G. x T45 Steel Tube - Set II

Tube No.	Station	Maximum	Position	Minimum	Position
2.1	1	+0.012	E - B	-0.012	A - D
	2	+0.007	E - B	-0.007	A - D
	3	+0.007	E - B	-0.007	A - D
	4	+0.004	E - B	-0.004	F - C
	5	+0.003	E - B	-0.003	F - C
	6	+0.004	E - B	-0.004	A - D
	7	+0.008	E - B	-0.008	A - D
	8	+0.019	A - D	-0.019	F - C
2.2	1	+0.011	E - B	-0.011	F - C
	2	+0.002	E - B	-0.002	A - D
	3	+0.005	A - D	-0.005	E - B
	4	+0.010	A - D	-0.010	E - B
	5	+0.008	A - D	-0.008	F - C
	6	+0.010	A - D	-0.010	F - C
	7	+0.016	E - B	-0.016	F - C
2.3	1	+0.018	F - C	-0.018	E - B
	2	+0.004	E - B	-0.004	A - D
	3	+0.005	E - B	-0.005	F - C
	4	+0.016	E - B	-0.016	F - C
	5	+0.016	E - B	-0.016	A - D
	6	+0.007	E - B	-0.007	A - D
	7	+0.026	A - D	-0.026	E - B
2.4	1	+0.023	A - D	-0.023	F - C
	2	+0.005	F - C	-0.005	A - D
	3	+0.007	F - C	-0.007	A - D
	4	+0.010	F - C	-0.010	A - D
	5	+0.002	F - C	-0.002	A - D
	6	+0.044	A - D	-0.044	F - C
2.5	1	+0.005	A - D	-0.005	E - B
	2	+0.009	A - D	-0.009	E - B
	3	+0.009	A - D	-0.009	E - B
	4	+0.008	A - D	-0.008	E - B
	5	+0.018	A - D	-0.018	E - B

APPENDIX IA (Contd)

Type No.	Station	Maximum	Position	Minimum	Position
2.6	1	+0.014	B - E	-0.014	A - D
	2	+0.014	F - C	-0.014	A - D
	3	+0.007	F - C	-0.007	A - D
	4	+0.003	F - C	-0.003	A - D
	5	+0.017	B - E	-0.017	A - D
2.7	1	+0.022	B - E	-0.022	F - C
	2	+0.004	B - E	-0.004	F - C
	3	+0.003	A - D	-0.003	F - C
	4	+0.018	B - E	-0.018	F - C
2.8	1	+0.005	F - C	-0.005	A - D
	2	+0.002	F - C	-0.002	A - D
	3	+0.006	B - E	-0.006	A - D
2.9	1	+0.008	F - C	-0.008	B - E
	2	+0.010	F - C	-0.010	B - E
2.10	1	+0.008	A - D	-0.008	F - C
2.11	1	+0.009	F - C	-0.009	A - D
2.12	1	+0.004	B - E	-0.004	A - D
2.13	1	+0.008	B - E	-0.008	F - C
2.14	1	+0.004	B - E	-0.004	F - C
2.15	1	+0.002	F - C	-0.002	A - D
2.16	1	+0.005	A - D	-0.005	E - B
2.17	1	+0.005	B - E	-0.005	A - D
2.18	1	+0.002	F - C	-0.002	A - D
2.19	1	+0.003	B - E	-0.003	F - C
2.20	1	+0.002	F - C	-0.002	B - E
2.21	1	+0.004	F - C	-0.004	A - D

Mechanical Properties of $2\frac{1}{4}$" Dia. x 24 S.W.G. x T45 Steel Tubes

Specimen No.	Direction of Grain	E x 10^{-6}	L.P.	0.1% P.S.	0.2% P.S.	0.5% P.S.	Max. Stress	Elongation % on 1"
1L2	L	29.1	29.8	41.6	41.8	42.0	44.3	10.0
1T1	T	28.6	27.3	40.1	42.1	45.6	45.9	4.0
2L1	L	30.7	29.5	40.6	40.8	41.0	41.7	10.0
2T1	T	31.05	26.4	42.3	44.1	45.3	45.9	4.0
3L1	L	29.2	29.9	41.7	41.8	42.1	42.8	8.0
3T2	T	31.9	25.6	46.0	48.5	50.7	52.7	3.0
4L1	L	28.6	26.5	40.6	41.0	41.5	43.5	8.0
4T1	T	30.2	27.6	46.6	48.9	50.1	54.4	4.0
5L2	L	28.4	29.0	43.7	44.6	45.2	46.4	6.0
5T1	T	29.9	27.5	47.4	49.7	51.4	52.3	3.0
6L1	L	29.2	26.6	42.8	43.3	43.8	46.6	6.0
6T1	T	29.8	25.9	45.4	46.9	47.8	48.2	4.0
7L1	L	30.1	20.7	44.3	45.2	46.4	48.9	6.0
7T2	T	28.7	29.4	47.4	49.7	51.5	53.3	4.0

APPENDIX IA (Contd)

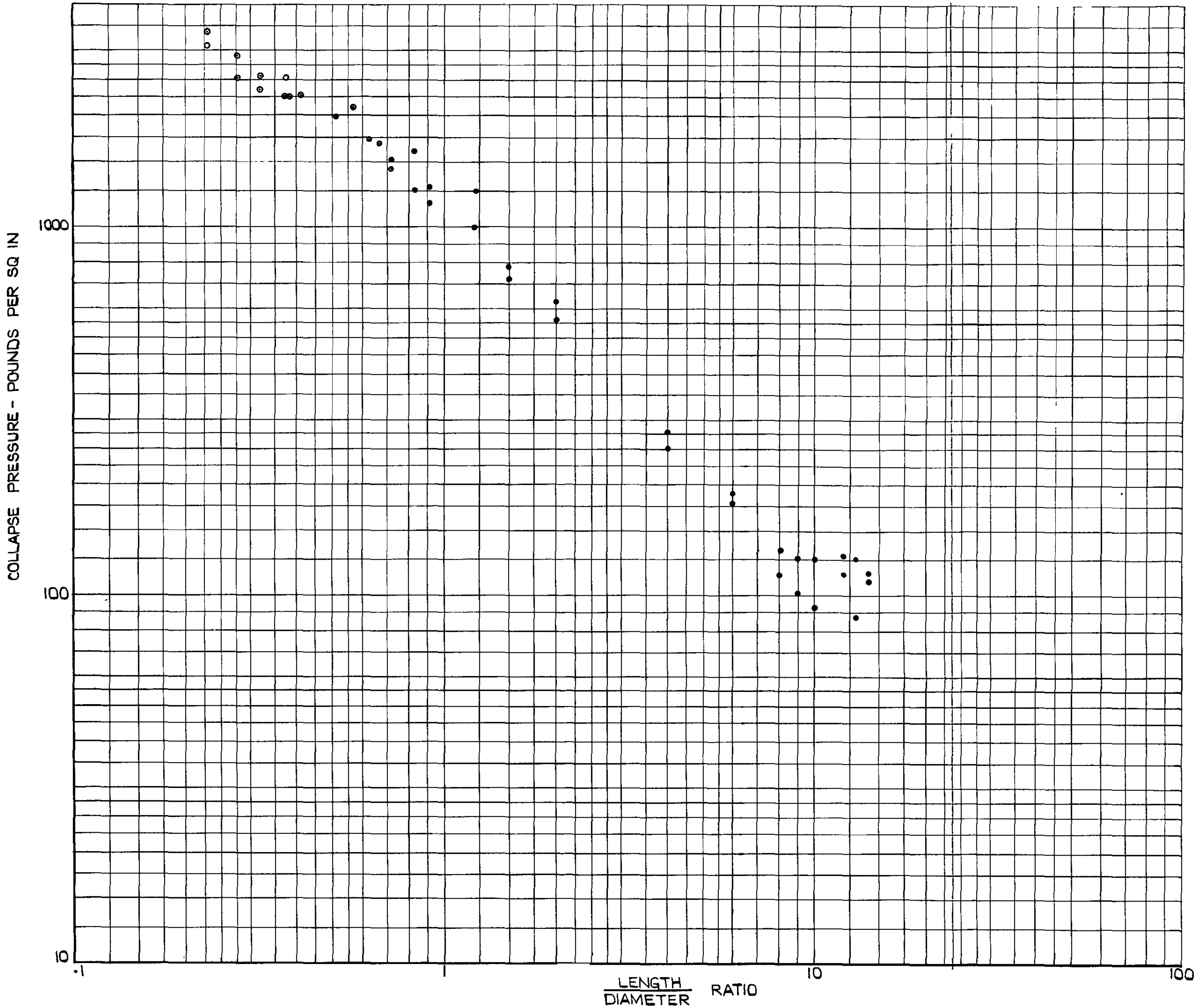
Relation Between Material Test and Pressure Test Specimens

Material Specimen No.	Relative Pressure Test Specimens
1	1.1, 4.1, 11.1.
2	3.1, 2.1, 7.1, 13.1.
3	5.1, 6.1, 8.1, 9.1, 10.1, 12.1, 14.1, 15.1.
4	18.1, 16.1, 17.1, 19.1, 20.1, 21.1, 1.2, 5.2.
5	4.2, 11.2, 8.2.
6	3.2, 6.2, 7.2, 9.2, 10.2.
7	12.2, 13.2, 14.2, 15.2, 16.2, 17.2, 18.2, 19.2, 20.2, 21.2, 2.2.

APPENDIX IA (Contd)

Results of Tests on 2.25" Dia. × 24 S.W.G. × T45 Steel Tubes under Uniform External Pressure on the Sides Only

Tube No.	Corrected Collapse Pressure	Effective Length	$\frac{L}{D}$	No. Lobes Actually Formed	Estimated No. Lobes in Complete Circumference
1.1 2.1	110 115	-	14	2 2	2 2
1.2 2.2	125 87	-	13	2 2	2 2
1.3 2.3	127 115	-	12	2 2	2 2
1.4 2.4	125 93	-	10	2 2	2 2
1.5 2.5	102 127	-	9	2 2	2 2
1.6 2.6	115 133	-	8	2 2	2 2
1.7 2.7	192 178	-	6	2 2	2 2
1.8 2.8	278 250	-	4	2 2	2 2
1.9 2.9	560 625	4.5	2	1 2	3 3
1.10 2.10	725 780	3.4	1.51	2 1	4 4
1.11 2.11	1250 995	2.35	1.045	2 2	4 4
1.12 2.12	1220 1160	2.05	0.91	3 2	5 5
1.13 2.13	1610 1250	1.88	0.835	3 2	5 5
1.14 2.14	1440 1510	1.62	0.72	2 4	5 5
1.15 2.15	1690 1760	1.5 1.4	0.667 0.622	3 5	6 6
1.16 2.16	2100 1990	1.28 1.15	0.57 0.51	2 5	6 6
1.17 2.17	2260 2240	0.93 0.86	0.413 0.382	2 4	6 6
1.18 2.18	2500 2240	0.85	0.378	2 3	6 6
1.19 2.19	2525 2325	0.72	0.32	2 2	6 6
1.20 2.20	2880 2500	0.62	0.276	2 1	6 6
1.21 2.21	3360 3080	0.52	0.23	5 6	7 7



GRAPHICAL PRESENTATION OF RESULTS OF TESTS ON $2\frac{1}{4}''$ DIA. X 24 S.W.G. X T 45 STEEL TUBES UNDER UNIFORM EXTERNAL PRESSURE APPLIED TO THE SIDES ONLY.

APPENDIX IB

Variation of Tube Thickness for 1.75" o/d x 22 s.w.g. x T45 Steel Tubes Showing Relation between Thickness and Collapse Pattern - Set A

Tube No.	Station	A	B	C	D	E	F	Mean
A1	1	0.031	0.030	0.029	0.029	0.030	0.031	0.030
	2	0.031	0.030	0.029	0.029	0.030	0.031	0.030
	3	0.031	0.030	0.028	0.028	0.029	0.030	0.0293
	4	0.031	0.030	0.028	0.028	0.029	0.031	0.0295
	5	0.031	0.030	0.028	0.028	0.029	0.030	0.0293
	6	0.031	0.029	0.028	0.029	0.030	0.031	0.0297
	7	0.031	0.030	0.028	0.029	0.030	0.031	0.03
	8	0.031	0.030	0.028	0.029	0.030	0.031	0.03
A2	1	0.028	0.029	0.030	0.031	0.030	0.029	0.0293
	2	0.028	0.029	0.030	0.031	0.030	0.029	0.0293
	3	0.028	0.028	0.029	0.030	0.030	0.029	0.029
	4	0.028	0.028	0.029	0.030	0.030	0.029	0.029
	5	0.028	0.028	0.029	0.030	0.030	0.029	0.029
	6	0.028	0.028	0.029	0.030	0.030	0.029	0.029
	7	0.028	0.028	0.030	0.031	0.031	0.029	0.0293
A3	1	0.029	0.029	0.031	0.031	0.030	0.030	0.03
	2	0.029	0.030	0.031	0.031	0.031	0.029	0.0301
	3	0.029	0.030	0.031	0.032	0.031	0.029	0.0303
	4	0.028	0.029	0.031	0.032	0.031	0.030	0.0301
	5	0.029	0.029	0.031	0.031	0.031	0.030	0.0301
	6	0.030	0.030	0.031	0.031	0.031	0.030	0.0305
A4	1	0.029	0.030	0.030	0.031	0.030	0.029	0.0298
	2	0.030	0.031	0.030	0.030	0.029	0.029	0.0298
	3	0.030	0.030	0.031	0.031	0.030	0.029	0.0301
	4	0.030	0.031	0.031	0.030	0.029	0.029	0.030
	5	0.030	0.031	0.031	0.030	0.029	0.029	0.030
A5	1	0.028	0.029	0.030	0.031	0.031	0.030	0.0298
	2	0.029	0.029	0.030	0.031	0.031	0.030	0.03
	3	0.029	0.030	0.030	0.031	0.031	0.030	0.0301
	4	0.029	0.029	0.030	0.031	0.031	0.030	0.03
A6	1	0.030	0.030	0.031	0.031	0.030	0.030	0.0303
	2	0.029	0.030	0.031	0.032	0.031	0.030	0.0305
	3	0.029	0.029	0.031	0.032	0.031	0.030	0.0303
A7	1	0.031	0.031	0.030	0.029	0.029	0.030	0.030
A8	1	0.029	0.029	0.030	0.031	0.031	0.030	0.030
A9	1	0.029	0.029	0.031	0.031	0.030	0.029	0.0298

APPENDIX IB (Contd)

Variations in Circularity of 1.75" dia. x 22 s.w.g. x T.45
Steel Tubes - Set G

Dimensions Show Maximum and Minimum Variations from Truly
Circular Fork in Thousandths of an Inch

Tube No.	Max.	Pos.	Min.	Pos.
G 1	+0.005	C/F	-0.016	AB/DE
2	+0.002	B/E	-0.005	CD/FA
3	+0.003	A/D	-0.008	BC/FE
4	+0.003	B-E	-0.005	CD/FA
5	+0.007	C-F	-0.011	DE/AB
6	+0.006	BC/EF	-0.008	CD/FA
7	+0.003	B-E	-0.006	CD/FA
8	+0.003	B-E	-0.005	C-F
9	+0.002	FA/CD	-0.004	B-E
10	+0.001	F-L	-0.004	B-E
11	+0.002	A-D	-0.005	BC/EF
12	+0.003	C-F	-0.005	DE/AB
13	+0.002	AB/DE	-0.006	BC/EF
14	+0.002	B-E	-0.005	A-D
15	+0.002	BC/EF	-0.005	A-D
16	+0.004	A-D	-0.008	C-F
17	+0.002	CD/FA	-0.004	B-E
18	+0.002	D-A	-0.006	B-E
19	+0.003	B-E	-0.005	D-A
20	+0.003	CD/FA	-0.007	AB/DE
21	+0.004	B-E	-0.006	CD/FA
22	+0.002	B-E	-0.004	C-F
23	+0.003	B-E	-0.007	C-F
24	+0.002	A-D	-0.003	C-F
25	+0.010	B-E	-0.008	CD/FA
26	+0.003	CD/FA	-0.003	DE/AB
27	+0.003	B-E	-0.003	C-F
28	+0.006	AB/ED	-0.005	C-F
29	+0.005	CD/FA	-0.006	B-E
30	+0.004	A-D	-0.005	AB/EF

Details of Damage Observed to 1.75" Dia. x 22 s.w.g. x T.45 Tubes

Tube No.	Details
A1	Slight bruise between stations 3-4 at position C-D
A1	Small cut between stations 6-7 at position F-A
A3	Bruise between stations 5-6 at position B-C
B2	Bruise between stations 3-4 at position E-A
G6	Bruise at end at position C

APPENDIX IB (Contd)

Variation of Tube Thickness for 1.75" o/d x 22 s.w.g. x T45 Steel Tubes Showing Relation between Thickness and Collapse Pattern - Set C

Tube No.	Station	A	B	C	D	E	F	Mean
C1	1	0.027	0.027	0.028	0.029	0.030	0.029	0.0283
	2	0.028	0.028	0.028	0.029	0.030	0.030	0.0288
	3	0.029	0.029	0.028	0.029	0.029	0.030	0.029
	4	0.029	0.029	0.029	0.028	0.028	0.029	0.0287
	5	0.030	0.030	0.029	0.028	0.028	0.029	0.029
	6	0.029	0.030	0.029	0.028	0.027	0.028	0.0285
	7	0.029	0.030	0.029	0.028	0.027	0.027	0.0283
	8	0.028	0.030	0.031	0.031	0.028	0.027	0.029
C2	1	0.028	0.027	0.028	0.029	0.030	0.030	0.0287
	2	0.028	0.027	0.027	0.028	0.030	0.030	0.0283
	3	0.029	0.028	0.027	0.027	0.029	0.030	0.0283
	4	0.029	0.029	0.028	0.027	0.028	0.029	0.0285
	5	0.030	0.030	0.029	0.027	0.028	0.029	0.0288
	6	0.029	0.029	0.029	0.028	0.028	0.028	0.0285
	7	0.029	0.030	0.030	0.029	0.028	0.028	0.029
C3	1	0.030	0.031	0.029	0.027	0.026	0.027	0.0283
	2	0.029	0.030	0.030	0.028	0.026	0.026	0.0281
	3	0.027	0.029	0.030	0.029	0.027	0.026	0.028
	4	0.027	0.028	0.030	0.030	0.028	0.027	0.0283
	5	0.025	0.028	0.031	0.030	0.027	0.025	0.0277
	6	0.026	0.028	0.030	0.030	0.028	0.026	0.028
C4	1	0.031	0.030	0.028	0.026	0.027	0.029	0.0285
	2	0.029	0.028	0.028	0.028	0.027	0.028	0.028
	3	0.030	0.028	0.028	0.027	0.027	0.029	0.0281
	4	0.028	0.027	0.027	0.028	0.029	0.029	0.028
	5	0.028	0.027	0.027	0.028	0.029	0.029	0.028
C5	1	0.030	0.030	0.029	0.028	0.028	0.029	0.029
	2	0.031	0.030	0.029	0.027	0.027	0.029	0.0288
	3	0.030	0.030	0.029	0.028	0.027	0.028	0.0287
	4	0.029	0.030	0.030	0.029	0.027	0.028	0.0288
C6	1	0.027	0.027	0.028	0.029	0.029	0.029	0.0281
	2	0.028	0.027	0.028	0.029	0.030	0.030	0.0287
	3	0.029	0.027	0.027	0.028	0.030	0.031	0.0287
C7	1	0.031	0.030	0.028	0.028	0.030	0.030	0.0295
C8	1	0.031	0.031	0.030	0.029	0.029	0.029	0.0298
C9	1	0.029	0.030	0.031	0.031	0.030	0.028	0.0298

<u>APPENDIX IB</u> (Contd)

<u>Variation of Tube Thickness for 1.75" o/d x 22 s.w.g. x T45 Steel Tubes Showing Relation between Thickness and Collapse Pattern - Set F</u>

Tube No.	A	B	C	D	E	F	Mean
F1	0.033	0.032	0.028	0.027	0.028	0.031	0.0298
F2	0.026	0.028	0.031	0.033	0.032	0.029	0.0298
F3	0.027	0.027	0.030	0.032	0.032	0.029	0.0295
F4	0.032	0.032	0.030	0.027	0.026	0.029	0.0293
F5	0.030	0.033	0.032	0.028	0.026	0.027	0.0293
F6	0.032	0.028	0.026	0.027	0.030	0.033	0.0293
F7	0.032	0.029	0.026	0.027	0.031	0.033	0.0295
F8	0.027	0.030	0.033	0.032	0.029	0.027	0.0297
F9	0.026	0.030	0.033	0.032	0.030	0.026	0.0295
F10	0.029	0.032	0.032	0.030	0.027	0.026	0.0293
F11	0.033	0.030	0.027	0.026	0.028	0.031	0.0291
F12	0.029	0.032	0.032	0.030	0.026	0.026	0.0291

APPENDIX IB (Contd)

Variation of Tube Thickness for 1.75" o/d x 22 s.w.g. x T45 Steel Tubes Showing Relation between Thickness and Collapse Pattern - Set G

Tube No.	A	B	C	D	E	F	Mean
1	0.028	0.031	0.034	0.034	0.031	0.028	0.031
2	0.032	0.029	0.028	0.030	0.033	0.034	0.031
3	0.028	0.030	0.034	0.034	0.031	0.029	0.031
4	0.028	0.028	0.032	0.034	0.034	0.030	0.031
5	0.028	0.030	0.033	0.034	0.031	0.029	0.0308
6	0.029	0.028	0.030	0.033	0.033	0.031	0.0307
7	0.030	0.033	0.034	0.032	0.029	0.028	0.031
8	0.028	0.030	0.032	0.034	0.033	0.030	0.031
9	0.028	0.029	0.032	0.034	0.033	0.030	0.031
10	0.028	0.030	0.033	0.034	0.031	0.029	0.0308
11	0.028	0.031	0.034	0.033	0.031	0.028	0.031
12	0.032	0.034	0.033	0.031	0.028	0.029	0.0308
13	0.029	0.030	0.033	0.034	0.031	0.029	0.031
14	0.030	0.032	0.033	0.033	0.030	0.028	0.031
15	0.033	0.030	0.028	0.028	0.031	0.033	0.0305
16	0.029	0.032	0.034	0.032	0.030	0.029	0.031
17	0.031	0.029	0.029	0.030	0.032	0.032	0.0305
18	0.029	0.031	0.033	0.032	0.031	0.028	0.0307
19	0.029	0.029	0.031	0.033	0.032	0.030	0.0307
20	0.031	0.033	0.032	0.030	0.029	0.029	0.0307
21	0.030	0.032	0.033	0.032	0.029	0.028	0.0307
22	0.033	0.031	0.029	0.029	0.030	0.032	0.0307
23	0.029	0.029	0.030	0.032	0.032	0.031	0.0307
24	0.028	0.029	0.032	0.033	0.032	0.029	0.0305
25	0.032	0.032	0.029	0.029	0.030	0.032	0.0308
26	0.029	0.029	0.030	0.033	0.033	0.030	0.0307
27	0.031	0.033	0.033	0.030	0.028	0.028	0.0305
28	0.032	0.030	0.028	0 029	0.032	0.033	0.0307
29	0.029	0.028	0.030	0.031	0.033	0.031	0.0303
30	0.031	0.028	0.029	0.031	0.032	0.032	0.0305

APPENDIX IB (Contd)

Variations in Circularity of 1.75" dia x 22 s.w.g. x T45 Steel Tube (Set A)

(All dimensions are in thousandths of an inch measured from the true circular form)

No.	Stn.	0°-180°	60°-240°	120°-300°	Max.	Pos.	Min.	Pos.
A 1	1	+2	+1½	+5½	+5½	26°	-6	124°
	2	-4	-2½	+6	+6½	113°	-5	15°
	3	-5	-2	+6	+7	111°	-5	23°
	4	-3½	-3	+5	+5½	115°	-4½	43°
	5	-3½	-2	+5	+5½	110°	-4	14°
	6	-6	-2	+6	+6½	112°	-7	171°
	7	-3	-1½	+3½	+4	103°	-3½	6°
	8	+1	+1½	-3½	+4½	30°	-3½	132°
A 2	1	-2	+4	-1	+4½	54°	-3½	162°
	2	+2½	-4	+2	+5	144°	-4	76°
	3	+2½	-4½	+1½	+6	147°	-4½	58°
	4	+2	-4	+1½	+5	143°	-4	75°
	5	+3	-4	+1½	+5½	149°	-4½	82°
	6	+2	-4	+2	+5	148°	-4	52°
	7	-4½	+5½	-1	+6½	65°	-5½	169°
A 3	1	+1	-2½	-5½	+4½	29°	-5	123°
	2	-1	-2	-2	-1	15°	-2	117°
	3	-2	-3	+1	+1	138°	-3	230°
	4	0	-3½	0	+2	144°	-3½	58°
	5	-1	-5½	+2½	+4	144°	-6	238°
	6	-½	+1½	-5	+3	37°	-7	132°
A 4	1	-1	+3½	-6	+4	50°	-6½	131°
	2	-2	-½	0	0	80°	-3	7°
	3	-2½	-1	+½	+1½	85°	-4½	226°
	4	+½	-2	-2½	+½	183°	-3	293°
	5	-½	+2½	-5½	+2½	51°	-6	132°
A 5	1	-4	+2	0	+5	82°	-3½	180°
	2	+7	-5	-1½	+8	167°	-6	82°
	3	+7	-5	-1½	+7	174°	-5½	83°
	4	-4	+2	+2	+4	90°	-4	180°
A 6	1	0	-2	-1	+½	163°	-2	274°
	2	+4	-4	-1	+4½	169°	-9	84°
	3	-½	-2½	-1	+1	148°	-4	229°
A 7	1	-3½	+4	-2½	+5	75°	-5½	180°
A 8	1	-3½	+2	+1½	+4	70°	-3½	0
A 9	1	0	-3	+2	+3	130°	-3	50°

Variation in Circularity of 1.75" dia x 22 s.w.g. x T45 Steel Tubes - Set B

(All dimensions are in thousandths of an inch from the true circular form)

No.	Stn.	0°-180°	60°-240°	120°-300°	Max.	Pos.	Min.	Pos.
B 1	1	0	+1	+2	+2½	104°	-½	175°
	2	+3½	+3	-1½	+4½	29°	-2½	115°
	3	+3	-1	+2	+3½	163°	-2	70°
	4	+3	0	+1	+3	0°	-1	80°
	5	+2	+2	-½	+3	207°	-½	113°
	6	+2	-1	+2½	+2½	134°	-1½	76°
	7	+2½	-½	+1	+2½	154°	-1	62°
	8	+4	+2	-2	+5½	28°	-2½	114°
B 2	1	+1½	-1½	+2½	+2½	133°	-1½	225°
	2	+½	+2	+2	+2½	106°	-½	215°
	3	+3½	+1	-1	+4	19°	-1	111°
	4	+5	+½	-1	+5½	14°	-3	71°
	5	+3½	+1	0	+3	185°	-1	130°
	6	+2	0	+1	+1½	162°	0	65°
	7	+4	-1½	+½	+4	177°	-1½	69°
B 3	1	+2	+5	+5	+6	100°	+1½	164°
	2	+7	+3½	+2½	+7	20°	+1½	82°
	3	+8	+4½	+1	+8½	19°	+½	102°
	4	+5½	+7½	0	+8	50°	+½	135°
	5	+6½	+5	+3	+3	30°	+3	120°
	6	+12	+2	0	+12	9°	-2½	96°
B 4	1	+4½	+½	+7½	+8	140°	-1	228°
	2	+7½	+1	+5	+8½	163°	+½	73°
	3	+10	+1	+3	+10	0°	-1	86°
	4	+11	+½	+2½	+11	180°	-1½	80°
	5	+10½	0	+2½	+10	184°	0	61°
B 5	1	-3	0	+4	+4	102°	-3	192°
	2	-½	-½	+1½	+2	122°	-1	190°
	3	0	-1	+1	+1	139°	-1	254°
	4	-2	0	+2	+3	102°	-2	196°
B 6	1	-1	+2	0	+2	88°	-3	161°
	2	-1	-1	+3	+4	115°	-3½	210°
	3	+2	+3½	-4½	+5	38°	-4½	125°
B 7	1	-1	+1	+2½	+3	100°	-1½	10°
B 8	1	-½	+½	+2	+2½	90°	-1	10°
B 9	1	+2	+2½	0	+2½	60°	+2	120°

APPENDIX IB (Contd)

Variations in Circularity of 1.75" dia x 22 s.w.g. x T45 Steel Tube - Set C

(All dimensions are in thousandths of an inch from the true circular form)

No.	Stn.	0°-180°	60°-240°	120°-300°	Max.	Pos.	Min.	Pos.
C 1	1	-2½	+1	+5½	+6½	98°	-3½	197°
	2	+2	0	+4	+4	144°	-2	40°
	3	+4	-1	+2½	+5	173°	-1½	67°
	4	+2½	+2	+2	+2½	153°	+1½	49°
	5	+2½	+½	+2	+3½	176°	+½	54°
	6	+3	-1	+3	+4½	162°	-1	60°
	7	+3	+2½	0	+3½	90°	-½	127°
	8	+4	+2	0	+4	0°	-1	102°
C 2	1	0	+½	+5	+5½	117°	-1	166°
	2	+½	+1	+4	+4	120°	0	60°
	3	+4	0	+1½	+4½	15°	-½	84°
	4	+4	+½	+1	+4	20°	-1½	93°
	5	+1½	+1½	+2½	+2½	124°	+1	160°
	6	+1½	-1	+4	+4½	124°	-1	230°
	7	+5½	-13	+9	+10	151°	-14	243°
C 3	1	-4½	-2	0	+1½	97°	-4½	180°
	2	-2½	-1	-1½	0	93°	-2½	149°
	3	-2	-½	-3	0	85°	-3	140°
	4	+7½	-9½	-2	+7½	0°	-12	85°
	5	+5½	-6	-5	+5½	0°	-9	97°
	6	-14	0	+8	+11	99°	-14½	195°
C 4	1	-2	-7½	+4½	+4	120°	-8½	230°
	2	-½	+1	-6	+3	45°	-6	138°
	3	-1	+2	-6	+4	45°	-7	134°
	4	-½	-1½	-4	+½	26°	-4½	110°
	5	-2	-12	+8½	+9	138°	-13	232°
C 5	1	+1	+1½	+2	+3	100°	-½	30°
	2	+2½	0	+2½	+2½	140°	-½	57°
	3	-1	+1	+3½	+4	100°	-1	193°
	4	0	+2	+2	+2½	108°	0	0
C 6	1	-8	-3	+5	+5	100°	-9½	20°
	2	+1	-3	-3	+2	33°	-3½	83°
	3	-4	-4½	-4½	+2½	150°	-7	45°
C 7	1	+1	+2½	+1½	+3	50°	+1	0
C 8	1	+3	-2	+3	+3½	90°	-4	40°
C 9	1	-3	+4	+4	+3½	60°	-3	0

APPENDIX IB (Contd)

Variations in Circularity of 1.75" Dia. x 22 S.W.G. x T.45 Steel Tubes - Set F

Dimensions Show Maximum and Minimum Variations from Truly Circular Form in Thousandths of an Inch

Tube No.	Max.	Pos.	Min.	Pos.
F_1	+0.002	BD/FA	-0.007	B/E
2	+0.001	A/D	-0.006	BC/EF
3	+0.005	B/E	-0.007	C/F
4	+0.005	B/E	-0.014	C/F
5	+0.003	BC/EF	-0.005	D/A
6	+0.003	CD/FA	-0.007	B/E
7	+0.001	CD/FA	-0.006	B/E
8	+0.004	B/E	-0.013	CD/FA
9	0	C/F	-0.005	D/A
10	+0.001	A/D	-0.010	BC/EF
11	0	B/E	-0.006	D/A
12	+0.002	B/E	-0.007	D/A

APPENDIX IB (Contd)

Variations in Circularity of 1.75" dia. x 22 s.w.g. x T.45 Steel Tubes - Set G

Dimensions Show Maximum and Minimum Variations from Truly Circular Fork in Thousandths of an Inch

Tube No.	Max.	Pos.	Min.	Pos.
G 1	+0.005	C/F	-0.016	AB/DE
2	+0.002	B/E	-0.005	CD/FA
3	+0.003	A/D	-0.008	BC/FE
4	+0.003	B-E	-0.005	CD/FA
5	+0.007	C-F	-0.011	DE/AB
6	+0.006	BC/EF	-0.008	CD/FA
7	+0.003	B-E	-0.006	CD/FA
8	+0.003	B-E	-0.005	C-F
9	+0.002	FA/CD	-0.004	B-E
10	+0.001	F-L	-0.004	B-E
11	+0.002	A-D	-0.005	BC/EF
12	+0.003	C-F	-0.005	DE/AB
13	+0.002	AB/DE	-0.006	BC/EF
14	+0.002	B-E	-0.005	A-D
15	+0.002	BC/EF	-0.005	A-D
16	+0.004	A-D	-0.008	C-F
17	+0.002	CD/FA	-0.004	B-E
18	+0.002	D-A	-0.006	B-E
19	+0.003	B-E	-0.005	D-A
20	+0.003	CD/FA	-0.007	AB/DE
21	+0.004	B-E	-0.006	CD/FA
22	+0.002	B-E	-0.004	C-F
23	+0.003	B-E	-0.007	C-F
24	+0.002	A-D	-0.003	C-F
25	+0.010	B-E	-0.008	CD/FA
26	+0.003	CD/FA	-0.003	DE/AB
27	+0.003	B-E	-0.003	C-F
28	+0.006	AB/ED	-0.005	C-F
29	+0.005	CD/FA	-0.006	B-E
30	+0.004	A-D	-0.005	AB/EF

Details of Damage Observed to 1.75" Dia. x 22 s.w.g. x T.45 Tubes

Tube No.	Details
A1	Slight bruise between stations 3-4 at position C-D
A1	Small cut between stations 6-7 at position F-A
A3	Bruise between stations 5-6 at position B-C
B2	Bruise between stations 3-4 at position E-A
G6	Bruise at end at position C

APPENDIX IB (Contd)

Mechanical Properties of $1\frac{3}{4}$" dia. x 22 s.w.g. x T45 Steel Tubes

Specimen No.	Direction of Grain	E x 10^{-6}	L.P.	0.1% PS	0.2% PS	0.5% PS	Max. Stress	Elongation % on 1"
1E1	L	28.8	27.1	43.4	43.8	44.3	45.2	8.0
	T	29.0	17.5	45.1	48.7	52.7	54.7	3.0
1E2	L	29.0	29.5	46.7	47.2	47.7	47.8	9.0
2E1	L	30.3	20.6	42.1	43.2	44.9	51.2	11.0
	T	29.1	22.1	42.6	45.1	47.7	53.0	7.0
2M	L	29.4	30.3	43.3	43.8	44.6	50.9	11.0
	T	29.4	15.5	42.0	45.2	48.2	52.3	7.0
3E1	L	29.3	27.9	42.7	43.1	43.3	46.7	13.0
	T	31.6	27.7	43.8	46.6	50.0	53.8	6.0
4E1	L	29.9	31.5	40.2	40.4	40.7	-	12.0
	T	32.3	18.3	41.7	44.4	47.5	51.2	7.0
	T	32.4	23.0	42.0	45.4	48.0	50.2	7.0
4E2	L	29.3	30.9	38.8	39.2	39.8	42.8	13.0
	T	30.2	25.7	42.6	43.9	45.8	49.0	6.0
5E1	L	32.2	23.3	50.7	52.0	52.7	53.3	6.0
	T	31.1	23.6	45.8	48.5	51.7	54.3	4.0
6E1	L	28.6	29.5	42.9	43.7	44.3	46.4	12.0
	T	31.6	25.5	44.2	46.5	49.2	53.0	8.0
7E1	L	30.2	26.4	44.9	45.4	46.0	50.7	11.0
8E1	L	30.6	31.3	47.8	48.4	48.8	52.7	11.0
	T	28.7	21.6	41.3	43.9	47.1	54.1	7.0

Suffix E1 Denotes Specimen from One End of Original Tube
" E2 " " " Other " " " "
" M " " " Middle " " "

L indicates Longitudinal test result

T indicates Transverse test result

Location of Specimens Relative to Sets of Test Specimen

Set No.	Specimen Set Number
A	1, 2
B	3, 4, 5
C	6, 7
F	8
G	8

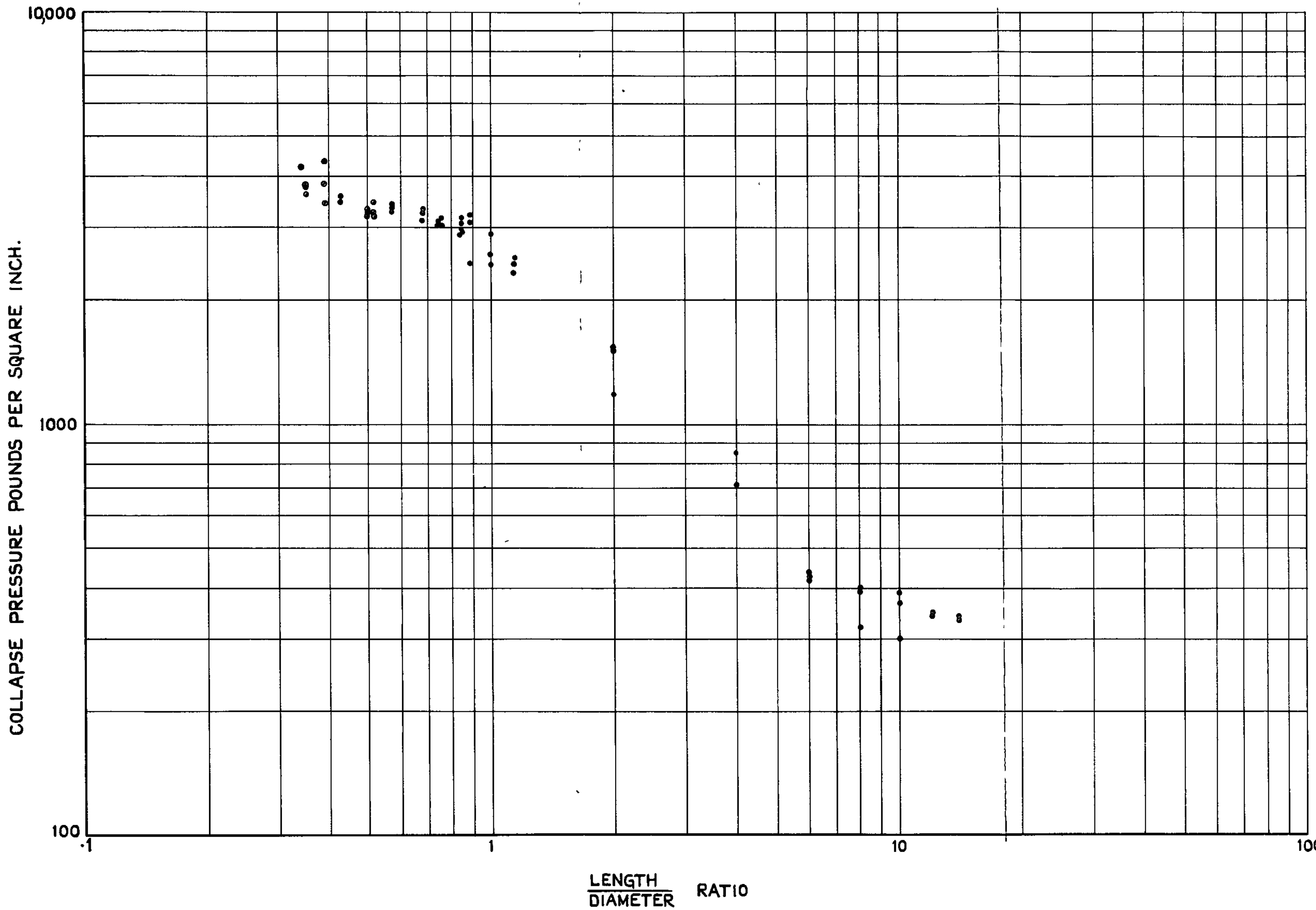
APPENDIX IB (Contd)

Results of Tests on $1\frac{3}{4}$" x 22 s.w.g. x T45
Steel Tube under Uniform External Pressure on Sides Only

Tube No.	Corrected Collapse Pressure	Effective Length	$\frac{L}{D}$	No. Lobes Actually Formed	Estimated No. Lobes in complete circumference
A1 B1 C1	- 334 339	- - -	14	- 2 2	- 2 2
A2 B2 C2	340 342 340	- - -	12	2 2 2	2 2 2
A3 B3 C3	367 387 300	- - -	10	2 2 2	2 2 2
A4 B4 C4	390 396 320	- - -	8	2 2 2	2 2 2
A5 B5 C5	425 420 433	- - -	6	2 2 2	2 2 2
A6 B6 C6	850 715 712	- - -	4	- 1 -	- 3 -
A7 B7 C7	1512 1360 1505	- - -	2	2 2 2	3 3 3
A8 B8 C8	3210 3100 2450	1.56 1.56 1.56	0.89	3 3 1	6 6 4
A9 B9 C9	4350 3450 3840	0.68 0.68 0.68	0.39	1 3 1	- 5 -
F1 F2 F5	3450 3240 3200	0.90 0.90 0.90	0.515	1 1 1	4 4 4
F3 F4 F6	3080 3015 3090	1.30 1.30 1.30	0.743	3 2 2	5 4 5
F7 F8 F9	3800 3750 3620	0.62 0.62 0.62	0.354	4 4 3	6 7 6

Tube No.	Corrected Collapse Pressure	Effective Length	L/D	No. Lobes Actually Formed	Estimated No. Lobes in complete circumference
G1 G2 G3	2320 2450 2520	2.00" 2.00" 2.00"	1.143	2 2 2	4 4 5
G4 G5 G6	2890 2420 2580	1.75 1.75 1.75	1	2 2 2	5 4 4
G7 G8 G9	3180 2900 3080	1.48 1.48 1.48	0.845	2 2 2	5 5 5
G10 G11 G12	3140 3120 3010	1.32 1.32 1.32	0.755	2 2 2	6 6 6
G13 G14 G15	3280 3320 3120	1.20 1.20 1.20	0.685	2 3 2	6 5-6 5-6
G16 G17 G18	3320 3280 3390	1.0 1.0 1.0	0.572	2 3 2	6 6 6
G19 G20 G21	3220 3330 3290	0.88 0.88 0.88	0.5	1 2 2	6 6 5-6
G22 G23 G24	3460 3520 3540	0.75 0.75 0.75	0.428	2 2 -	7 6 -

Attached: Drg. SME.74715/R



GRAPHICAL PRESENTATION OF RESULTS OF TESTS ON $1\frac{3}{4}''$ DIA. x 22 S.W.G. x T45 STEEL TUBE UNDER UNIFORM EXTERNAL PRESSURE APPLIED TO THE SIDES ONLY.

APPENDIX IC

Variation in Tube Thickness for 1" dia. x 24 S.W.G. x T45 Steel Tubes Showing Relation Between Wall Thickness and Collapse Pattern - Set 1

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.025	0.025	0.024	0.023	0.023	0.024	0.024
	2	"	"	"	"	"	"	0.024
	3	"	"	"	"	0.024	0.025	0.0243
	4	"	"	"	0.024	"	0.024	0.0242
2	1	0.025	0.025	0.024	0.023	0.023	0.024	0.024
	2	0.025	0.025	0.024	0.023	0.024	0.024	0.0242
	3	0.025	0.025	0.025	0.024	0.024	0.024	0.0245
3	1	0.023	0.023	0.024	0.025	0.025	0.024	0.024
	2	0.023	0.023	0.024	0.025	0.025	0.024	0.024
	3	0.024	0.023	0.024	0.025	0.025	0.025	0.0243
4	1	0.024	0.024	0.023	0.023	0.024	0.024	0.0237
5	1	0.024	0.024	0.023	0.023	0.024	0.024	0.0237
6	1	0.024	0.024	0.024	0.023	0.023	0.024	0.0237
7	1	0.024	0.024	0.023	0.023	0.024	0.024	0.0237
8	1	0.024	0.024	0.024	0.023	0.024	0.024	0.0238
9	1	0.024	0.024	0.024	0.024	0.023	0.024	0.0238
10	1	0.023	0.023	0.024	0.025	0.024	0.024	0.0238
11	1	0.024	0.024	0.024	0.024	0.024	0.024	0.024
12	1	0.024	0.024	0.024	0.024	0.024	0.024	0.024

APPENDIX IC (Contd)

Variations in Tube Thickness for 1" dia. x 24 S.W.G. x T45 Steel Tube Showing Relation Between Wall Thickness and Collapse Pattern - Set 2

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.023	0.024	0.024	0.025	0.025	0.024	0.0242
	2	"	"	"	"	"	"	0.0242
	3	0.024	"	0.025	"	"	"	0.0245
	4	0.023	"	"	"	"	"	0.0243
2	1	0.024	0.025	0.025	0.026	0.025	0.023	0.0247
	2	0.024	0.025	0.026	0.025	0.024	0.024	0.0247
	3	0.024	0.025	0.026	0.026	0.025	0.024	0.025
3	1	0.023	0.024	0.024	0.025	0.025	0.024	0.0242
	2	0.023	0.024	0.025	0.025	0.025	0.024	0.0243
	3	0.023	0.024	0.025	0.025	0.025	0.024	0.0243
4	1	0.024	0.024	0.024	0.024	0.025	0.025	0.0243
5	1	0.023	0.024	0.025	0.025	0.024	0.023	0.024
6	1	0.024	0.025	0.025	0.024	0.024	0.024	0.0243
7	1	0.024	0.024	0.024	0.024	0.024	0.024	0.024
8	1	0.024	0.024	0.024	0.024	0.025	0.025	0.0243
9	1	0.025	0.025	0.025	0.024	0.024	0.024	0.0245
10	1	0.025	0.025	0.024	0.023	0.023	0.024	0.024
11	1	0.024	0.025	0.025	0.025	0.024	0.023	0.0243
12	1	0.024	0.024	0.023	0.024	0.024	0.025	0.024

Variations of Tube Thickness for 1" dia. x 24 S.W.G. x T45 Steel Tubes Showing Relation Between Wall Thickness and Collapse Pattern - Set 3

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.023	0.024	0.024	0.024	0.023	0.023	0.0235
	2	"	"	0.025	0.025	0.024	0.024	0.0242
	3	"	"	"	0.024	"	0.024	0.024
	4	"	"	"	0.024	"	0.023	0.0238
2	1	0.022	0.023	0.025	0.025	0.024	0.023	0.0237
	2	0.022	0.023	0.025	0.025	0.024	0.023	0.0237
	3	0.023	0.024	0.025	0.025	0.024	0.023	0.024
3	1	0.022	0.022	0.023	0.025	0.025	0.023	0.0233
	2	0.022	0.022	0.023	0.025	0.025	0.024	0.0235
	3	0.023	0.022	0.024	0.025	0.025	0.024	0.0238
4	1	0.022	0.022	0.024	0.025	0.025	0.024	0.0237
5	1	0.022	0.023	0.025	0.025	0.024	0.023	0.0237
6	1	0.026	0.025	0.023	0.022	0.023	0.025	0.024
7	1	0.025	0.024	0.022	0.023	0.024	0.025	0.0238
8	1	0.024	0.023	0.022	0.023	0.024	0.025	0.0235
9	1	0.025	0.024	0.023	0.022	0.023	0.024	0.0235
10	1	0.025	0.024	0.023	0.022	0.023	0.024	0.0235
11	1	0.025	0.024	0.023	0.022	0.023	0.024	0.0235
12	1	0.025	0.024	0.023	0.023	0.024	0.025	0.024

APPENDIX IC (Contd)

Variations of Wall Thickness for 1" dia. x 24 S.W.G. x T45 Steel Tubes Showing Relation Between Wall Thickness and Collapse Pattern - Set 4

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.024	0.024	0.024	0.023	0.024	0.024	0.0238
	2	0.025	0.024	0.024	0.023	0.024	0.025	0.0242
	3	0.024	0.024	0.024	0.023	0.024	0.024	0.0238
	4	0.025	0.025	0.025	0.023	0.024	0.024	0.0243
	5	0.025	0.025	0.024	0.024	0.024	0.025	0.0245
	6	0.025	0.025	0.024	0.024	0.024	0.024	0.0243
	7	0.025	0.025	0.024	0.024	0.024	0.024	0.0243
	8	0.025	0.025	0.024	0.023	0.024	0.024	0.0242
2	1	0.025	0.024	0.024	0.023	0.024	0.025	0.0242
	2	0.025	0.024	0.024	0.023	0.024	0.025	0.0242
	3	0.024	0.024	0.024	0.023	0.024	0.025	0.024
	4	0.024	0.024	0.024	0.023	0.024	0.024	0.0238
	5	0.025	0.024	0.024	0.024	0.024	0.025	0.0243
	6	0.024	0.024	0.024	0.024	0.024	0.025	0.0242
	7	0.025	0.025	0.024	0.024	0.024	0.025	0.0245
3	1	0.023	0.024	0.025	0.025	0.024	0.023	0.024
	2	0.024	0.025	0.024	0.024	0.024	0.024	0.0242
	3	0.023	0.025	0.025	0.024	0.024	0.024	0.0242
	4	0.024	0.024	0.025	0.025	0.024	0.024	0.0243
	5	0.023	0.025	0.025	0.025	0.024	0.024	0.0243
	6	0.024	0.024	0.025	0.024	0.024	0.024	0.0242
	7	0.023	0.024	0.025	0.025	0.024	0.023	0.024
4	1	0.024	0.025	0.024	0.024	0.023	0.024	0.024
	2	0.024	0.024	0.025	0.024	0.024	0.024	0.0242
	3	0.026	0.025	0.024	0.024	0.023	0.024	0.0243
	4	0.025	0.025	0.025	0.024	0.024	0.024	0.0245
	5	0.025	0.024	0.025	0.024	0.024	0.024	0.0243
	6	0.025	0.025	0.025	0.024	0.024	0.024	0.0245
5	1	0.025	0.025	0.025	0.024	0.023	0.024	0.0243
	2	0.024	0.024	0.025	0.024	0.024	0.024	0.0242
	3	0.024	0.025	0.025	0.025	0.024	0.024	0.0245
	4	0.025	0.025	0.025	0.024	0.024	0.025	0.0247
	5	0.025	0.025	0.025	0.024	0.024	0.024	0.0245
	6	0.025	0.025	0.024	0.024	0.024	0.024	0.0243

Tube No.	Station	A	B	C	D	E	F	Mean
6	1	0.023	0.024	0.024	0.024	0.024	0.024	0.0238
	2	0.023	0.024	0.024	0.025	0.024	0.024	0.024
	3	0.023	0.023	0.024	0.025	0.025	0.024	0.024
	4	0.024	0.024	0.024	0.024	0.024	0.024	0.024
	5	0.024	0.024	0.024	0.024	0.024	0.024	0.024
7	1	0.024	0.024	0.024	0.023	0.024	0.024	0.0238
	2	0.024	0.024	0.024	0.024	0.024	0.024	0.024
	3	0.024	0.024	0.024	0.024	0.024	0.024	0.024
	4	0.025	0.024	0.024	0.024	0.024	0.024	0.0242
	5	0.024	0.024	0.024	0.024	0.024	0.024	0.024

APPENDIX IC (Contd)

Variation of Wall Thickness for 1" dia. × 24 S.W.G. × T45 Steel Tubes Showing Relation Between Wall Thickness and Collapse Pattern - Set 5

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.024	0.024	0.024	0.024	0.024	0.024	0.024
	2	0.024	0.024	0.024	0.024	0.024	0.024	0.024
	3	0.024	0.024	0.025	0.025	0.024	0.024	0.0243
	4	0.024	0.024	0.025	0.024	0.024	0.024	0.0242
	5	0.024	0.025	0.024	0.024	0.024	0.024	010242
	6	0.024	0.025	0.025	0.024	0.024	0.024	0.0243
	7	0.024	0.024	0.025	0.025	0.024	0.024	0.0243
	8	0.024	0.025	0.024	0.024	0.024	0.024	0.0242
2	1	0.024	0.024	0.024	0.024	0.024	0.024	0.024
	2	0.024	0.024	0.024	0.024	0.023	0.024	0.0238
	3	0.024	0.024	0.024	0.024	0.024	0.024	0.024
	4	0.024	0.024	0.024	0.024	0.023	0.024	0.0238
	5	0.024	0.025	0.025	0.024	0.024	0.024	0.0243
	6	0.024	0.024	0.025	0.024	0.024	0.024	0.0242
	7	0.024	0.024	0.024	0.024	0.024	0.024	0.024
3	1	0.024	0.024	0.023	0.023	0.024	0.025	0.0238
	2	0.024	0.023	0.023	0.024	0.025	0.025	0.024
	3	0.025	0.024	0.024	0.024	0.024	0.024	0.0242
	4	0.025	0.024	0.023	0.022	0.023	0.025	0.0237
	5	0.024	0.023	0.023	0.024	0.025	0.025	0.024
	6	0.025	0.024	0.024	0.024	0.025	0.025	0.0245
	7	0.024	0.024	0.024	0.024	0.025	0.025	0.0243
4	1	0.023	0.023	0.024	0.025	0.025	0.024	0.024
	2	0.023	0.024	0.024	0.025	0.024	0.024	0.024
	3	0.023	0.023	0.024	0.024	0.024	0.024	0.0237
	4	0.023	0.024	0.025	0.025	0.024	0.023	0.024
	5	0.023	0.023	0.024	0.025	0.025	0.024	0.024
	6	0.024	0.024	0.024	0.025	0.024	0.024	0.0242
5	1	0.023	0.024	0.025	0.025	0.024	0.023	0.024
	2	0.024	0.025	0.025	0.025	0.023	0.023	0.0242
	3	0.024	0.025	0.025	0.024	0.023	0.023	0.024
	4	0.024	0.025	0.025	0.024	0.023	0.023	0.024
	5	0.024	0.025	0.025	0.024	0.023	0.023	0.024
	6	0.024	0.025	0.025	0.024	0.023	0.023	0.024
6	1	0.023	0.023	0.024	0.025	0.025	0.023	0.0238
	2	0.022	0.023	0.024	0.025	0.025	0.024	0.0238
	3	0.022	0.023	0.024	0.025	0.024	0.024	0.0237
	4	0.022	0.023	0.024	0.025	0.025	0.025	0.024
	5	0.023	0.023	0.024	0.025	0.025	0.024	0.024
	6	0.023	0.023	0.024	0.025	0.025	0.024	0.024
7	1	0.022	0.023	0.024	0.026	0.025	0.024	0.024
	2	0.023	0.022	0.023	0.025	0.026	0.024	0.0238
	3	0.023	0.022	0.024	0.025	0.025	0.024	0.0238
	4	0.023	0.023	0.024	0.025	0.025	0.024	0.024
	5	0.023	0.023	0.024	0.025	0.025	0.024	0.024

Variations of Wall Thickness for 1" dia. x 24 S.W.G. x T45 Steel Tubes Showing Relation Between Wall Thickness and Collapse Pattern - Set 6

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.024	0.025	0.024	0.024	0.023	0.024	0.024
	2	0.024	0.024	0.024	0.024	0.024	0.024	0.024
	3	0.025	0.025	0.025	0.024	0.024	0.025	0.0247
	4	0.025	0.025	0.025	0.024	0.024	0.024	0.0245
2	1	0.023	0.023	0.024	0.024	0.024	0.024	0.024
	2	0.023	0.023	0.023	0.024	0.025	0.024	0.024
	3	0.023	0.024	0.025	0.025	0.024	0.024	0.0247
	4	0.024	0.024	0.025	0.025	0.025	0.025	0.0245
3	1	0.024	0.023	0.023	0.023	0.024	0.025	0.0237
	2	0.025	0.024	0.023	0.024	0.025	0.025	0.0243
4	1	0.024	0.023	0.023	0.024	0.025	0.025	0.024
5	1	0.025	0.024	0.023	0.023	0.023	0.024	0.0237

Variations of Wall Thickness for 1" dia. x 24 S.W.G. x T45 Steel Tubes Showing Relation Between Wall Thickness and Collapse Pattern - Set 7

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.024	0.024	0.023	0.023	0.024	0.024	0.0237
	2	0.024	0.024	0.023	0.023	0.024	0.024	0.0237
	3	0.024	0.024	0.024	0.024	0.024	0.024	0.024
	4	0.025	0.025	0.024	0.024	0.024	0.025	0.0245
2	1	0.024	0.024	0.024	0.024	0.024	0.024	0.024
	2	0.024	0.023	0.024	0.024	0.024	0.024	0.0238
	3	0.024	0.024	0.024	0.024	0.024	0.024	0.024
	4	0.024	0.024	0.024	0.024	0.024	0.024	0.024
3	1	0.024	0.025	0.025	0.024	0.023	0.023	0.024
	2	0.024	0.025	0.025	0.024	0.023	0.023	0.024
4	1	0.023	0.023	0.023	0.024	0.025	0.024	0.0237
5	1	0.023	0.024	0.024	0.025	0.024	0.023	0.0238

APPENDIX IC (Contd)

Variations of Wall Thickness for 1" dia. x 24 S.W.G. x T45 Steel Tubes Showing Relation Between Wall Thickness and Collapse Pattern - Set 8

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.024	0.023	0.023	0.024	0.025	0.025	0.024
	2	0.025	0.025	0.025	0.025	0.026	0.025	0.025
2	1	0.024	0.024	0.023	0.023	0.024	0.024	0.0237
	2	0.025	0.024	0.024	0.023	0.024	0.025	0.0242
3	1	0.025	0.024	0.023	0.023	0.023	0.024	0.024
4	1	0.023	0.023	0.023	0.024	0.025	0.024	0.0237
5	1	0.024	0.024	0.024	0.024	0.024	0.024	0.024
6	1	0.023	0.023	0.024	0.025	0.025	0.024	0.024
7	1	0.025	0.024	0.023	0.023	0.024	0.024	0.0238
8	1	0.023	0.023	0.024	0.024	0.024	0.023	0.0235

APPENDIX IC (Contd)

Maximum and Minimum Variation from the True Circular Form of 1" dia. x 24 S.W.G. x T45 Steel Tubes - Set 1

Tube No.	Station	Max.	Position	Min.	Position
1	1	+0.002	B-E	-0.002	A-D
	2	+0.002	C-F	-0.002	B-E
	3	+0.002	C-F	-0.002	B-E
	4	+0.002	B-E	-0.002	C-F
2	1	Nil	-	Nil	-
	2	+0.001	E-B	-0.001	A-D
	3	+0.002	E-B	-0.002	A-D
3	1	Nil	-		
	2	+0.001	A-D	-0.001	B-E
	3	+0.001	F-C	-0.001	B-E
4	1	Nil	-	Nil	-
5	1	+0.001	E-B	-0.001	A-D
6	1	+0.001	A-D	-0.001	C-F
7	1	+0.001	B-E	-0.001	C-F
8	1	+0.002	A-D	-0.002	C-F
9	1	+0.002	A-D	-0.002	B-E
10	1	Nil	-	Nil	-
11	1	+0.009	B-E	-0.009	A-D
12	1	+0.007	F-C	-0.007	A-D

APPENDIX IC (Contd)

Maximum and Minimum Variations from Truly Circular Form of 1" dia. x 24 S.W.G. x T45 Steel Tubes - Set 2

Tube No.	Station	Max.	Position	Min.	Position
1	1	+0.003	A-D	-0.003	C-F
	2	+0.002	"	-0.002	B-E
	3	+0.001	"	-0.001	B-E
	4	+0.003	"	-0.003	B-E
2	1	Nil	-	Nil	-
	2	+0.001	F-C	-0.001	B-E
	3	+0.001	F-C	-0.001	B-E
3	1	+0.001	F-C	-0.001	E-B
	2	+0.002	F-C	-0.002	E-B
	3	+0.001	F-C	-0.001	E-B
4	1	+0.002	B-E	-0.002	F-C
5	1	+0.003	A-D	-0.003	F-C
6	1	+0.001	F-C	-0.001	A-D
7	1	+0.003	F-C	-0.003	B-E
8	1	+0.001	E-B	-0.001	A-D
9	1	+0.001	B-E	-0.001	F-C
10	1	+0.002	E-B	-0.002	D-A
11	1	Nil	-	Nil	-
12	1	+0.001	A-D	-0.001	F-C

Maximum and Minimum Variations from Truly Circular Form of 1" dia. x 24 S.W.G. x T45 Steel Tubes - Set 3

Tube No.	Station	Max.	Position	Min.	Position
1	1	+0.001	F-C	-0.001	B-E
	2	+0.001	B-E	-0.001	A-D
	3	Nil	-	Nil	-
	4	+0.001	A-D	-0.001	B-E
2	1	+0.002	F-C	-0.002	A-D
	2	+0.001	F-C	-0.001	A-D
	3	+0.002	B-E	-0.002	F-C
3	1	+0.002	A-D	-0.002	B-E
	2	+0.003	A-D	-0.003	B-E
	3	+0.003	A-D	-0.003	B-E
4	1	+0.002	A-D	-0.002	F-C
5	1	+0.001	F-C	-0.001	B-E
6	1	+0.001	A-D	-0.001	B-E
7	1	+0.001	B-E	-0.001	A-D
8	1	+0.001	A-D	-0.001	B-E
9	1	+0.001	F-C	-0.001	A-D
10	1	+0.001	A-D	-0.001	B-E
11	1	+0.002	B-E	-0.002	F-C
12	1	Nil	-	Nil	-

APPENDIX IC (Contd)

Maximum and Minimum Variation from Truly Circular Form of 1" dia. x 24 S.W.G. x T45 Steel Tubes - Set 4

Tube No.	Station	Max.	Position	Min.	Position
1	1	+0.001	EB	-0.001	F-C
	2	Nil	-	Nil	-
	3	+0.001	AD	-0.001	F-C
	4	"	"	"	"
	5	"	"	"	"
	6	"	E-B	"	"
	7	"	A-D	"	"
	8	+0.003	"	-0.003	E-B
2	1	Nil	-	Nil	-
	2	Nil	-	Nil	-
	3	+0.001	F-C	-0.001	E-B
	4	"	F-C	"	A-D
	5	"	A-D	"	F-C
	6	+0.003	"	-0.003	F-C
	7	+0.002	"	-0.002	E-B
3	1	+0.001	F-C	-0.001	E-B
	2	"	"	"	E-B
	3	"	"	"	A-D
	4	"	"	"	A-D
	5	"	A-D	"	E-B
	6	+0.005	A-D	-0.005	F-C
	7	+0.002	F-C	-0.002	E-B
4	1	+0.001	A-D	-0.001	E-B
	2	+0.002	F-C	-0.002	"
	3	"	A-D	"	"
	4	"	"	"	"
	5	"	"	"	"
	6	"	"	"	"
5	1	+0.003	F-C	-0.003	E-B
	2	+0.003	A-D	-0.003	"
	3	+0.002	F-C	-0.002	"
	4	+0.001	A-D	-0.001	"
	5	+0.002	F-C	-0.002	A-D
	6	"	"	-0.002	E-B
6	1	Nil	-	Nil	-
	2	+0.002	A-D	-0.002	E-B
	3	Nil	-	Nil	-
	4	+0.002	F-C	-0.002	A-D
	5	"	"	"	E-B
7	1	+0.001	A-D	-0.001	F-C
	2	+0.001	A-D	-0.001	E-B
	3	Nil	-	Nil	-
	4	"	-	-	-
	5	"	-	-	-

APPENDIX IC (Contd)

Maximum and Minimum Variation from Truly Circular Form of 1" dia. x 24 S.W.G. x T45 Steel Tubes - Set 5

Tube No.	Station	Max.	Position	Min.	Position
1	1	Nil	-	Nil	-
	2	Nil	-	Nil	-
	3	+0.001	F-C	-0.001	A-D
	4	"	B-E	-0.001	"
	5	"	F-C	-0.001	"
	6	Nil	-	Nil	-
	7	+0.001	F-C	-0.001	A-D
	8	+0.001	"	-0.001	B-E
2	1	Nil	-	Nil	-
	2	+0.001	F-C	-0.001	A-D
	3	+0.002	B-E	-0.002	"
	4	"	"	"	"
	5	"	F-C	"	E-B
	6	"	"	"	"
	7	+0.001	B-E	-0.001	A-D
3	1	+0.002	A-D	-0.002	F-C
	2	"	"	"	B-E
	3	"	"	"	F-C
	4	+0.004	"	-0.004	F-C
	5	+0.002	"	-0.002	F-C
	6	+0.004	"	-0.004	F-C
	7	+0.001	"	-0.001	"
4	1	+0.001	B-E	-0.001	F-C
	2	+0.002	A-D	-0.002	B-E
	3	"	F-C	-0.002	B-E
	4	+0.003	B-E	-0.003	F-C
	5	"	"	"	F-C
	6	+0.001	"	-0.001	A-D
5	1	+0.001	F-C	-0.001	A-D
	2	"	"	-0.001	"
	3	Nil	-	Nil	-
	4	"	-	"	-
	5	"	-	"	-
	6	+0.002	F-C	-0.002	A-D
6	1	+0.001	A-D	-0.001	F-C
	2	+0.001	"	-0.001	"
	3	+0.002	"	-0.002	"
	4	+0.002	E-B	-0.002	A-D
	5	+0.001	F-C	-0.001	A-D
	6	+0.002	"	-0.002	E-B
7	1	+0.001	A-D	-0.001	E-B
	2	+0.002	F-C	-0.002	"
	3	"	E-B	-0.002	F-C
	4	+0.001	"	-0.001	A-D
	5	"	"	-0.001	"

Maximum and Minimum Variation from True Circular Form of 1" dia. x 24 S.W.G. x T45 Steel Tube - Set 6

Tube No.	Station	Max.	Position	Min.	Position
1	1	+0.011	F-C	-0.011	A-D
	2	+0.003	F-C	-0.003	A-D
	3	+0.001	B-E	-0.001	F-C
	4	+0.001	F-C	-0.001	A-D
2	1	+0.002	A-D	-0.002	F-C
	2	+0.001	"	-0.001	B-E
	3	"	"	"	"
	4	"	F-C	"	"
3	1	+0.002	F-C	-0.002	B-E
	2	+0.001	B-E	-0.001	A-D
4	1	+0.001	A-D	-0.001	B-E
5	1	+0.002	B-E	-0.002	F-C

Maximum and Minimum Variations from True Circular Form of 1" dia. x 24 S.W.G. x T45 Steel Tubes - Set 7

Tube No.	Station	Max.	Position	Min.	Position
1	1	+0.001	B-E	-0.001	F-C
	2	Nil	-	Nil	-
	3	Nil	-	"	-
	4	+0.001	A-D	-0.001	F-C
2	1	+0.001	B-E	-0.001	F-C
	2	Nil	-	Nil	-
	3	"	-	"	-
	4	"	-	"	-
3	1	+0.002	B-E	-0.002	A-D
	2	+0.002	B-E	-0.002	F-C
4	1	+0.001	A-D	-0.001	F-C
5	1	+0.002	A-D	-0.002	F-C

Maximum and Minimum Variations from True Circular Forming

1" dia. x 24 S.W.G. x T45 Steel Tubes - Set 8

Tube No.	Station	Max.	Position	Min.	Position
1	1	+0.002	A-D	-0.002	F-C
	2	+0.001	E-B	-0.001	F-C
2	1	+0.001	B-E	-0.001	F-C
		+0.005	B-E	-0.005	A-D
3	1	+0.001	F-C	-0.001	E-B
4	1	Nil	-	Nil	-
5	1	+0.001	F-C	-0.001	A-D
6	1	Nil	-	Nil	-
7	1	+0.001	A-D	-0.001	E-B
8	1	+0.001	F-C	-0.001	A-D

APPENDIX IC (Contd)

Mechanical Properties of 1" dia. x 24 S.W.G. x T45 Steel Tubes

Specimen No.	Direction of Grain	E $\times 10^{-6}$	LP	0.1% PS	0.2% PS	0.5% PS	Max. Stress	Elong. % on 1"
1	L	29.3	29.2	46.2	47.0	47.9	49.1	9
	T	27.3	17.2	45.9	49.0	50.4	53.2	3
2	L	28.7	32.4	46.2	47.0	47.7	49.6	9
	T	28.5	22.2	44.9	48.0	49.2	50.1	2
3	L	30.2	28.8	47.7	48.2	48.9	50.1	6
	T	29.0	21.7	46.1	49.0	51.0	53.5	4

Relation Between Mechanical and Actual Test Specimens

Mechanical Test Specimen No.	Relative Test Specimen Set
1	1
2	2
3	3

As the mechanical properties of the three test specimens were so uniform, sets 4 to 8 of the actual test specimens were cut at random from the remaining lengths of tube.

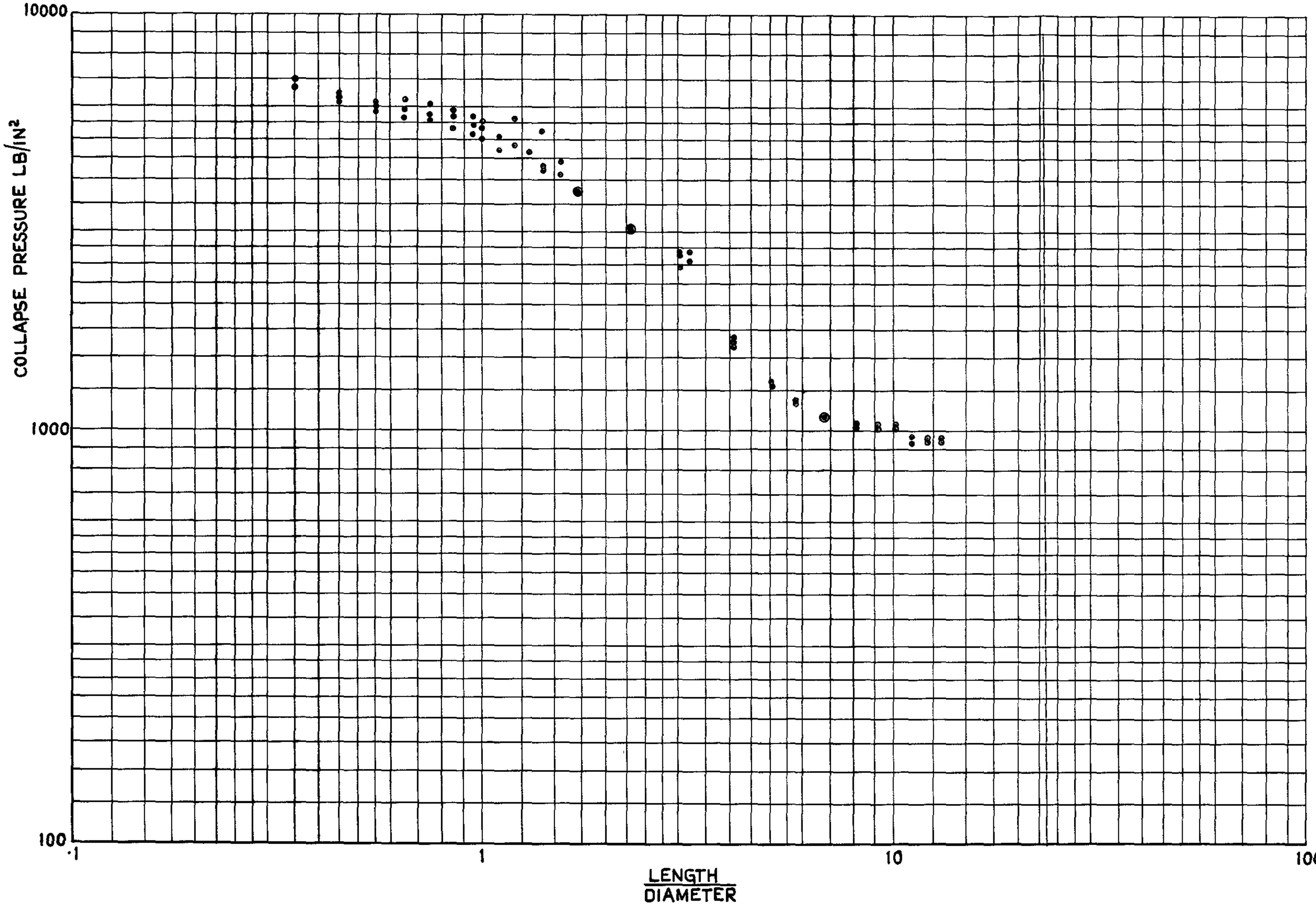
APPENDIX IC (Contd)

Results of Tests on 1" dia. x 24 S.W.G. x T45 Steel Tubes Under Uniform Pressure Applied to the Sides Only

Tube No.	L/D	Collapse Pressure	No. Lobes Formed	Estimated No. in Periphery
4.2 5.2	13.05	960 965	2 2	2 2
4.3 5.3	12.05	965 950	2	2
4.4 5.4	11.05	950 975	2	2
4.5 5.5	10.05	1020 1015	2	2
4.6 5.6	9.05	1000 1025	2	2
4.7 5.7	8.05	1040 1033	2	2
6.1 7.1	6.8	1080 1085	2	2
6.2 7.2	5.8	1170 1180	2	2
2.1 3.1	5.05	1300 1315	2	2
1.2 2.2 3.2	4.1	1630 1660 1675	2	2
8.1 8.2	3.2	2580 2670	2 3	3 3
1.3 2.3 3.3	3.05	2650 2670 2460	3 3 3	3 3 3
6.3 7.3	2.3	3080 3080	3 3	3 3
6.4 7.4	1.7	3760 3750	3 4	3 4
1.4 2.4	1.55	4400 4135	4 4	4 4
6.5 7.5	1.4	4230 4280	4 4	4 4
8.3 8.4	1.3	4650 5240	4 4	4 4
8.5 8.6	1.2	5650 4850	4 4	4 4
8.7 8.8	1.1	5100 4750	4 4	4 4
1.5 2.5 3.5	1.0	5300 5500 4950	4 4 4	4 4 4
1.6 2.6 3.6	0.95	5400 5600 5100	4 4 4	4 4 4
1.7 2.7 3.7	0.85	5640 5875 5275	4 4 4	4 4 4

Tube No.	L/D	Collapse Pressure	No. Lobes Formed	Estimated No. in Periphery
1.8 2.8 3.8	0.75	5730 6000 5540	4 4 4	4 4 4
1.9 2.9 3.9	0.65	5875 6225 5680	4 4 3	4 4 4
1.10 2.10 3.10	0.55	6000 6150 5965	3 3 3	4 4 4
1.11 2.11 3.11	0.45	6200 6325 6425	1 3 2	6 4 4
1.12 2.12 3.12	0.35	6700 - 6900	4 - 1	7-8 - -

Attached: Drg. S.M.E. 74799/R



RESULTS OF TESTS ON 1" DIA. X 24 S.W.G. X T.45 STEEL TUBES UNDER EXTERNAL PRESSURE APPLIED TO THE SIDES ONLY.

APPENDIX ID

Variation of Wall Thickness for 1" O/D × 22 S.W.G. × T45 Steel Tubes showing relation between Wall Thickness and Collapse Pattern - Set 1

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.032	0.030	0.031	0.032	0.034	0.034	0.0321
	2	0.032	0.030	0.031	0.033	0.034	0.034	0.0323
	3	0.032	0.031	0.031	0.032	0.033	0.034	0.0321
	4	0.032	0.031	0.031	0.032	0.033	0.033	0.032
	5	0.032	0.030	0.031	0.032	0.033	0.033	0.0318
	6	0.032	0.031	0.031	0.032	0.033	0.033	0.032
	7	0.032	0.031	0.031	0.032	0.033	0.033	0.032
	8	0.032	0.031	0.031	0.032	0.033	0.033	0.032
2	1	0.032	0.032	0.031	0.030	0.030	0.031	0.031
	2	0.032	0.032	0.031	0.030	0.030	0.031	0.031
	3	0.032	0.032	0.030	0.030	0.030	0.031	0.0308
	4	0.032	0.032	0.031	0.030	0.030	0.031	0.031
	5	0.032	0.032	0.031	0.030	0.030	0.031	0.031
	6	0.032	0.032	0.031	0.030	0.030	0.031	0.031
	7	0.032	0.032	0.032	0.031	0.030	0.031	0.0313
3	1	0.030	0.031	0.032	0.032	0.032	0.031	0.0313
	2	0.030	0.031	0.031	0.032	0.031	0.031	0.031
	3	0.030	0.030	0.032	0.032	0.032	0.030	0.031
	4	0.030	0.030	0.031	0.032	0.032	0.030	0.0308
	5	0.030	0.030	0.031	0.032	0.032	0.030	0.0308
	6	0.030	0.030	0.031	0.032	0.032	0.031	0.031
4	1	0.032	0.032	0.031	0.031	0.031	0.031	0.0313
	2	0.032	0.031	0.031	0.031	0.031	0.032	0.0313
	3	0.032	0.031	0.031	0.030	0.030	0.031	0.0308
	4	0.032	0.032	0.030	0.030	0.030	0.031	0.0308
	5	0.032	0.031	0.030	0.030	0.031	0.031	0.0308

APPENDIX ID (Contd)

Tube No.	Station	A	B	C	D	E	F	Mean
5	1	0.031	0.030	0.030	0.031	0.031	0.032	0.0308
	2	0.031	0.030	0.030	0.031	0.032	0.032	0.031
	3	0.031	0.030	0.030	0.030	0.032	0.032	0.0308
	4	0.032	0.031	0.030	0.030	0.031	0.032	0.031
	5	0.032	0.030	0.030	0.031	0.032	0.032	0.0311
6	1	0.030	0.030	0.030	0.031	0.032	0.032	0.0308
	2	0.030	0.030	0.030	0.031	0.032	0.031	0.0307
	3	0.030	0.030	0.030	0.032	0.032	0.031	0.0308
	4	0.030	0.030	0.031	0.031	0.032	0.031	0.0308
7	1	0.030	0.031	0.032	0.032	0.031	0.030	0.031
	2	0.030	0.031	0.032	0.031	0.030	0.030	0.0307
	3	0.030	0.031	0.032	0.032	0.031	0.030	0.031
8	1	0.030	0.031	0.032	0.032	0.031	0.031	0.0311
9	1	0.030	0.031	0.032	0.031	0.031	0.031	0.031
10	1	0.032	0.031	0.031	0.031	0.031	0.032	0.0313
11	1	0.030	0.031	0.031	0.032	0.031	0.031	0.031
12	1	0.031	0.030	0.030	0.031	0.032	0.031	0.0308
13	1	0.030	0.030	0.030	0.031	0.031	0.031	0.0305
14	1	0.030	0.030	0.031	0.031	0.030	0.030	0.0303

APPENDIX ID (Contd)

Variation of Wall Thickness for 1" O/D × 22 S.W.G. × T45 Steel Tubes
Showing Relation between Collapse Pattern and Wall Thickness - Set 2

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.030	0.033	0.033	0.033	0.032	0.030	0.0318
	2	0.031	0.034	0.034	0.032	0.031	0.030	0.032
	3	0.031	0.033	0.033	0.032	0.031	0.030	0.0316
	4	0.030	0.031	0.033	0.034	0.033	0.030	0.0318
	5	0.030	0.032	0.033	0.034	0.033	0.031	0.0321
	6	0.031	0.032	0.033	0.033	0.033	0.031	0.0321
	7	0.031	0.031	0.032	0.033	0.034	0.032	0.0321
	8	0.031	0.032	0.033	0.033	0.033	0.031	0.0321
2	1	0.031	0.033	0.033	0.032	0.031	0.030	0.0316
	2	0.032	0.033	0.033	0.032	0.031	0.030	0.0318
	3	0.031	0.032	0.033	0.033	0.031	0.030	0.0316
	4	0.030	0.031	0.032	0.033	0.032	0.030	0.0313
	5	0.031	0.033	0.033	0.032	0.031	0.030	0.0316
	6	0.032	0.033	0.032	0.031	0.030	0.031	0.0313
	7	0.031	0.033	0.033	0.032	0.031	0.030	0.0316
3	1	0.031	0.033	0.033	0.032	0.032	0.031	0.032
	2	0.030	0.032	0.033	0.034	0.032	0.031	0.032
	3	0.031	0.033	0.033	0.032	0.031	0.031	0.0318
	4	0.031	0.033	0.032	0.031	0.030	0.030	0.0311
	5	0.030	0.032	0.033	0.033	0.032	0.030	0.0316
	6	0.030	0.032	0.033	0.033	0.032	0.030	0.0316
4	1	0.030	0.032	0.034	0.033	0.031	0.030	0.0316
	2	0.030	0.032	0.033	0.033	0.032	0.030	0.0316
	3	0.030	0.032	0.033	0.033	0.032	0.030	0.0316
	4	0.030	0.032	0.033	0.033	0.032	0.030	0.0315
	5	0.031	0.032	0.033	0.032	0.031	0.030	0.0313

APPENDIX ID (Contd)

Tube No.	Station	A	B	C	D	E	F	Mean
5	1	0.031	0.030	0.031	0.032	0.034	0.033	0.0318
	2	0.031	0.030	0.031	0.032	0.034	0.032	0.0316
	3	0.030	0.030	0.031	0.033	0.033	0.032	0.0315
	4	0.030	0.032	0.033	0.033	0.033	0.031	0.032
	5	0.030	0.030	0.031	0.033	0.033	0.032	0.0313
6	1	0.033	0.032	0.031	0.030	0.032	0.033	0.0318
	2	0.033	0.033	0.033	0.032	0.032	0.031	0.0323
	3	0.032	0.033	0.033	0.032	0.030	0.030	0.0316
	4	0.031	0.033	0.033	0.033	0.031	0.030	0.0318
7	1	0.031	0.033	0.034	0.032	0.030	0.030	0.0316
	2	0.031	0.033	0.033	0.031	0.030	0.030	0.0313
	3	0.031	0.033	0.034	0.033	0.031	0.030	0.032
8	1	0.031	0.033	0.033	0.032	0.030	0.030	0.0315
9	1	0.033	0.032	0.030	0.031	0.032	0.033	0.0318
10	1	0.030	0.031	0.032	0.033	0.033	0.031	0.0316
11	1	0.030	0.030	0.032	0.033	0.033	0.031	0.0315
12	1	0.030	0.030	0.032	0.033	0.033	0.032	0.0316
13	1	0.033	0.032	0.030	0.030	0.032	0.033	0.0316
14	1	0.030	0.030	0.033	0.034	0.033	0.031	0.0318

APPENDIX ID (Contd)

Variations in Wall Thickness for 1" Dia. x 22 S.W.G. x T45 Steel Tube Showing Relation between Wall Thickness and Collapse Pattern - Set 3

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.032	0.031	0.030	0.030	0.031	0.032	0.031
	2	0.032	0.031	0.031	0.031	0.031	0.032	0.0313
	3	0.032	0.031	0.031	0.031	0.031	0.032	0.0313
	4	0.032	0.031	0.031	0.030	0.030	0.031	0.0308
	5	0.032	0.032	0.031	0.030	0.030	0.031	0.031
	6	0.032	0.031	0.031	0.030	0.030	0.031	0.0308
	7	0.032	0.031	0.031	0.030	0.031	0.032	0.0311
	8	0.032	0.032	0.031	0.031	0.031	0.032	0.0315
2	1	0.031	0.031	0.032	0.032	0.032	0.030	0.0313
	2	0.030	0.031	0.032	0.032	0.031	0.030	0.031
	3	0.030	0.031	0.032	0.032	0.031	0.030	0.031
	4	0.031	0.031	0.032	0.032	0.031	0.030	0.0311
	5	0.031	0.031	0.032	0.032	0.031	0.031	0.0313
	6	0.031	0.031	0.032	0.032	0.031	0.031	0.0313
	7	0.032	0.031	0.032	0.032	0.031	0.031	0.0315
3	1	0.032	0.032	0.031	0.030	0.031	0.031	0.0311
	2	0.032	0.032	0.032	0.030	0.030	0.031	0.0311
	3	0.032	0.032	0.031	0.031	0.031	0.031	0.0313
	4	0.032	0.032	0.031	0.030	0.031	0.032	0.0313
	5	0.032	0.032	0.031	0.031	0.031	0.032	0.0318
	6	0.032	0.032	0.032	0.031	0.031	0.031	0.0315
4	1	0.032	0.033	0.031	0.030	0.030	0.031	0.0311
	2	0.032	0.032	0.031	0.031	0.030	0.031	0.0311
	3	0.032	0.032	0.032	0.031	0.030	0.031	0.0313
	4	0.032	0.032	0.032	0.031	0.031	0.031	0.0315
	5	0.032	0.032	0.032	0.031	0.031	0.031	0.0315

APPENDIX ID (Contd)

Tube No.	Station	A	B	C	D	E	F	Mean
5	1	0.030	0.031	0.032	0.032	0.032	0.031	0.0313
	2	0.030	0.030	0.032	0.033	0.032	0.031	0.0313
	3	0.030	0.031	0.032	0.033	0.032	0.031	0.0315
	4	0.030	0.031	0.032	0.033	0.032	0.031	0.0315
	5	0.031	0.031	0.032	0.033	0.032	0.031	0.0316
6	1	0.032	0.032	0.032	0.031	0.030	0.031	0.0313
	2	0.032	0.032	0.032	0.031	0.031	0.031	0.0315
	3	0.032	0.033	0.032	0.031	0.031	0.031	0.0316
	4	0.032	0.033	0.032	0.031	0.030	0.031	0.0315
7	1	0.030	0.031	0.033	0.033	0.031	0.030	0.0313
	2	0.030	0.032	0.033	0.033	0.031	0.030	0.0315
	3	0.031	0.032	0.033	0.033	0.031	0.031	0.0318
8	1	0.031	0.032	0.033	0.032	0.030	0.031	0.0315
9	1	0.031	0.030	0.030	0.031	0.033	0.032	0.031
10	1	0.030	0.031	0.033	0.033	0.031	0.030	0.0313
11	1	0.030	0.031	0.033	0.033	0.031	0.030	0.0313
12	1	0.030	0.030	0.031	0.033	0.033	0.031	0.0313
13	1	0.030	0.030	0.030	0.032	0.033	0.032	0.0311
14	1	0.031	0.033	0.033	0.031	0.030	0.030	0.0313

APPENDIX ID (Contd)

Maximum and Minimum Variation from True Circular Form of 1" Dia. × 22 S.W.G. × T45 Steel Tubes - Set 1

Tube No.	Station	Maximum	Position	Minimum	Position
1	1	+0.003	B-E	+0.002	C-F
	2	+0.003	AB-ED	+0.002	CD-FA
	3	+0.003	B-E	+0.002	BC-FA
	4	+0.003	B-E	+0.002	BC-FE
	5	+0.003	A-D	+0.002	FE-CB
	6	+0.003	F-C	+0.002	AB-DE
	7	+0.003	A-D	+0.001	A-D
	8	+0.002	B-E	0	A-D
2	1	+0.002	B-E	+0.002	C-F
	2	0	-	0	-
	3	+0.002	B-E	+0.001	FA-CD
	4	0	-	0	-
	5	+0.003	B-E	+0.001	F-C
	6	+0.002	B-E	0	A-D
	7	+0.005	C-F	-0.001	AB-DE
3	1	+0.002	B-E	+0.001	FA-CD
	2	+0.002	F-C	+0.001	B-E
	3	+0.002	F-C	+0.001	B-E
	4	+0.002	F-C	+0.001	B-E
	5	+0.002	F-C	+0.001	B-E
	6	+0.002	F-C	+0.001	A-D
4	1	+0.002	B-E	+0.001	F-C
	2	+0.002	F-C	+0.001	A-D
	3	0	-	0	-
	4	+0.002	F-C	+0.001	B-E
	5	+0.003	F-C	-0.007	AB-DE
5	1	0	-	0	-
	2	0	-	0	-
	3	+0.002	B-E	+0.001	F-C
	4	+0.002	B-E	+0.001	A-D
	5	0	-	0	-
6	1	0	-	0	-
	2	0	-	0	-
	3	+0.002	A-D	+0.001	EF-B-C
	4	0	-	0	-
7	1	0	-	0	-
	2	+0.001	B-E	0	F-C
	3	+0.001	B-E	0	F-C
8	1	+0.001	B-E	0	F-C
9	1	0	-	0	-
10	1	+0.002	B-E	0	A-D
11	1	+0.002	F-C	0	A-D
12	1	+0.001	A-D	0	BC-EF
13	1	+0.002	B-E	0	F-C
14	1	+0.002	B-E	0	F-C

APPENDIX ID (Contd)

Maximum and Minimum Variation from True Circular Form of 1" Dia. × 22 S.W.G. × T45 Steel Tubes - Set 2

Tube No.	Station	Maximum	Position	Minimum	Position
1	1	+0.002	B-E	+0.001	F-C
	2	+0.002	D-A	+0.001	F-C
	3	+0.002	F-C	+0.001	A-D
	4	+0.002	F-C	+0.001	B-E
	5	+0.002	B-E	+0.001	A-D
	6	0	-	0	
	7	0	-	0	
	8	0	-	0	
2	1	0	-	0	-
	2	+0.002	B-E	+0.001	F-C
	3	0	-	0	-
	4	+0.002	F-C	+0.001	B-E
	5	+0.002	F-C	+0.001	B-E
	6	+0.002	B-E	+0.001	A-D
	7	+0.002	A-B	+0.001	F-C
3	1	+0.002	B-E	0	F-C
	2	0	-	0	-
	3	+0.002	B-E	+0.001	F-C
	4	+0.002	F-C	+0.001	A-D
	5	+0.002	A-D	+0.001	F-C
	6	0	-	0	-
4	1	0	-	0	-
	2	0	-	0	-
	3	+0.002	F-C	+0.001	B-E
	4	+0.002	B-E	+0.001	F-C
	5	+0.002	B-E	+0.001	F-C
5	1	+0.002	B-E	+0.001	F-C
	2	+0.002	B-E	+0.001	F-C
	3	+0.002	A-D	+0.001	F-C
	4	0	-	0	-
	5	+0.002	F-C	+0.001	B-E
6	1	0	-	0	-
	2	+0.002	F-C	+0.001	A-D
	3	+0.001	A-D	0	B-E
	4	+0.002	A-D	+0.001	B-E
7	1	+0.002	B-E	0	A-D
	2	+0.002	F-C	+0.001	B-E
	3	0	0	0	-
8	1	0	-	0	-
9	1	+0.002	A-D	+0.001	F-C
10	1	0	-	0	-
11	1	+0.001	A-D	0	F-C
12	1	+0.001	F-C	0	-
13	1	0	-	0	-
14	1	0	-	0	-

APPENDIX ID (Contd)

Maximum and Minimum Variation from True Circular Form of 1" Dia. × 22 S.W.G. × T45 Steel Tubes - Set 3

Tube No.	Station	Maximum	Position	Minimum	Position
1	1	+0.002	A-D	0	B-E
	2	+0.001	F-C	0	B-E
	3	+0.002	A-D	0	F-C
	4	+0.001	F-C	0	B-E
	5	+0.001	A-D	-0.001	B-E
	6	+0.001	A-D	0	F-C
	7	+0.001	A-D	0	F-C
	8	+0.002	A-D	0	BC-EF
2	1	+0.001	A-D	0	B-E
	2	+0.002	F-C	0	A-D
	3	+0.001	F-C	0	B-E
	4	+0.001	F-C	0	A-D
	5	+0.001	F-C	0	A-D
	6	+0.002	F-C	-0.001	B-E
	7	+0.006	F-C	-0.009	AB-DE
3	1	+0.001	A-D	0	F-C
	2	+0.001	B-E	0	A-D
	3	+0.001	B-E	0	A-D
	4	+0.001	B-E	0	F-C
	5	+0.001	B-E	0	A-D
	6	+0.001	B-E	0	A-D
4	1	+0.001	A-D	0	B-E
	2	+0.002	A-D	0	F-C
	3	+0.002	A-D	0	F-C
	4	+0.001	B-E	0	F-C
	5	+0.002	B-E	0	F-C
5	1	+0.002	A-D	-0.001	B-E
	2	+0.001	A-D	0	B-E
	3	+0.002	A-D	0	B-E
	4	+0.001	B-E	0	A-D
	5	+0.002	A-D	0	F-C
6	1	+0.001	A-D	0	F-C
	2	+0.002	F-C	0	A-D
	3	+0.001	B-E	0	A-D
	4	+0.002	B-E	-0.001	A-D
7	1	+0.002	A-D	-0.001	B-E
	2	0	-	0	-
	3	+0.002	A-D	0	BC-EF
8	1	+0.002	A-D	-0.001	B-E
9	1	0	-	0	-
10	1	+0.001	A-D	0	C-F
11	1	+0.002	F-C	-0.001	B-E
12	1	+0.001	A-D	0	BC-EF
13	1	+0.003	AB-DE	-0.001	BC-EF
14	1	0	-	0	-

Mechanical Properties of 1" × 22 S.W.G. × T45 Tubes

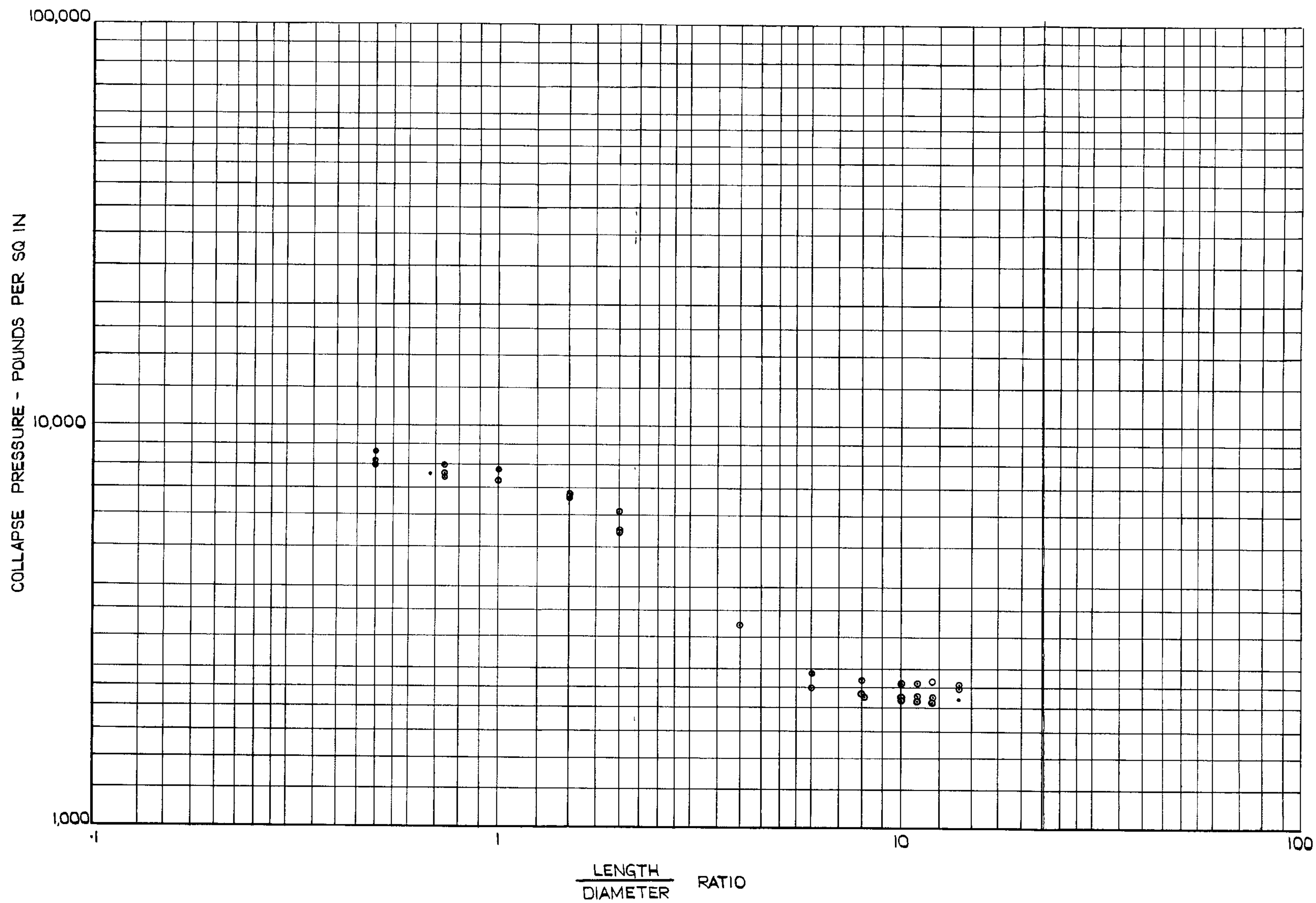
Specimen No.	Direction of Grain	E	L.P.	6.1% P.S.	0.2% P.S.	0.5% P.S.	Max. Stress	Elongation
1	L	29.0	36.2	47.8	48.1	48.2	48.8	10.0
	T	31.4	22.3	50.0	51.7	52.6	53.0	2.0
2	L	29.0	41.2	49.8	50.3	50.4	50.6	9.0
	T	29.6	27.7	52.0	53.9	55.4	55.4	4.0
3	L	28.3	38.8	47.2	48.0	48.3	48.7	8.0
	T	29.8	20.1	50.4	52.7	54.3	54.3	4.0

Location of Mechanical Test Specimens Relative to Pressure Test Specimens

Mechanical Test Specimen No.	Relative Pressure Test Set
1	1
2	2
3	3

Results of Tests on 1" Dia. × 22 S.W.G. × T45 Steel Tubes under Uniform External Pressure applied to the Sides Only

Tube No.	Corrected Collapse Pressure	Effective Length	L/D	No. Lobes Actually Formed	Estimated No. Lobes in Complete Pheriphery
1.1	2210		14	2	2
2.1	2280			2	2
3.1	2090			2	2
1.2	2110		12	2	2
2.2	2310			2	2
3.2	2070			2	2
1.3	2090		10	2	2
2.3	2300			2	2
3.3	2120			2	2
1.4	2090		9	2	2
2.4	2290			2	2
3.4	2100			2	2
1.5	2120		8	2	2
2.5	2330			2	2
3.5	2150			2	2
1.6	2240	5.98	5.98	2	2
2.6	2450			2	2
3.6	2270			2	2
1.7	2865	4.0	4.0	2	2
2.7	3200			2	2
3.7	2860			2	2
1.8	6225	2.0	2.0	3	3
2.8	6125			3	3
3.8	5425			3	3
1.9	6675	1.48	1.48	4	4
2.9	6575			4	4
3.9	6600			4	4
1.10	7730	1.0	1.0	4	4
2.10	7200			4	4
3.10	7280			4	4
1.11	7960	0.74	0.74	4	4
2.11	7480			1	4
3.11	7570			1	4
1.12	8580	0.5	0.5	1	5
2.12	8080			1	5
3.12	8160			1	5



RESULTS OF TESTS ON 1" DIA. X 22 S.W.G. X T45 STEEL TUBES UNDER UNIFORM EXTERNAL PRESSURE APPLIED TO THE SIDES ONLY.

APPENDIX IE

Variation in Wall Thickness for 1" Dia. × 20 S.W.G. × T45 Steel Tubes Showing Relation Between Wall Thickness and Collapse Pattern. Set 1

Tube No.	Station	A	B	C	D	E	F	Mean
1.1	1	0.0405	0.040	0.0395	0.04075	0.0415	0.042	0.0407
	2	0.041	"	"	0.0405	"	0.04225	0.0408
	3	"	"	0.039	"	"	"	0.0407
	4	"	"	0.0395	0.04075	"	"	0.0408
	5	"	"	"	0.041	"	0.042	0.0408
	6	0.04125	"	0.03975	"	0.04225	"	0.041
	7	0.041	"	"	"	0.042	0.04225	0.041
	8	"	"	"	"	0.0425	0.0425	0.041
1.2	1	0.041	0.03975	0.0395	0.041	0.04175	0.042	0.0408
	2	"	0.040	"	"	0.042	0.0415	0.0408
	3	"	"	0.03975	"	0.04175	0.042	0.0408
	4	"	0.0395	0.03925	0.0405	0.0415	0.04175	0.0406
	5	0.04125	0.040	0.040	0.041	0.042	0.04225	0.0411
	6	0.04075	"	"	0.04125	"	0.042	0.041
	7	0.04125	"	"	0.0395	0.04075	"	0.0405
1.3	1	0.041	0.04025	0.042	0.042	0.041	0.040	0.041
	2	0.0405	0.041	"	"	0.04125	"	0.0411
	3	0.040	0.0405	"	"	"	"	0.041
	4	"	"	"	"	0.041	0.04025	0.041
	5	"	"	0.04175	"	"	0.040	0.0409
	6	"	"	0.0415	"	"	0.041	0.041
	7	"	"	0.042	0.0425	"	0.040	0.041
1.4	1	0.039	0.04025	0.0425	0.043	0.0415	0.040	0.041
	2	"	"	0.042	"	"	"	"
	3	"	0.040	"	"	0.042	"	"
	4	0.03925	0.0395	0.0415	"	"	0.03975	0.0408
	5	0.039	0.040	0.042	"	"	0.040	0.041
	6	"	0.03975	"	0.0435	0.04275	"	0.0412
	7	0.03925	0.040	"	0.043	0.04225	0.041	0.0412
1.5	1	0.040	0.0425	0.043	0.042	0.040	0.040	0.0412
	2	"	0.04225	0.0425	"	0.04025	"	0.0412
	3	0.03975	0.04125	"	"	0.0405	0.03925	0.0409
	4	0.040	0.042	"	"	"	"	0.041
	5	"	"	"	"	0.040	0.040	0.0411
	6	"	"	"	"	0.04025	"	0.0411
1.6	1	0.041	0.0425	0.0425	0.04075	0.04025	0.0395	0.0411
	2	"	0.043	"	0.041	0.039	0.03925	0.0410
	3	0.0405	0.0425	"	0.0405	"	"	0.0407
	4	0.041	"	"	0.04075	0.03925	0.0395	0.0409
	5	0.0405	"	0.04225	0.04125	0.03925	"	0.0409
1.7	1	0.042	0.043	0.042	0.040	0.040	0.040	0.0412
	2	0.0415	0.0425	"	0.041	"	"	"
	3	"	0.04225	"	"	"	0.0395	0.041
	4	0.041	"	0.04225	"	0.0395	0.03925	0.0409
	5	0.04125	"	0.042	0.04025	"	0.0395	0.0408
1.8	1	0.040	0.039	0.040	0.0415	0.04225	0.042	0.0408
	2	0.0405	"	0.03925	0.041	0.04275	0.04275	0.0409
	3	0.040	"	0.039	0.0405	0.042	0.04225	0.0405
	4	"	"	"	0.041	0.0425	0.04225	0.0406

APPENDIX IE (Contd)

Tube No.	Station	A	B	C	D	E	F	Mean
1.9	1	0.03925	0.03925	0.0405	0.0425	0.042	0.041	0.0408
	2	0.0395	0.03925	0.04025	0.042	0.04225	0.04125	"
	3	0.0395	0.0395	0.04075	0.0425	0.0425	0.04125	0.041
	4	0.03925	0.03925	0.0405	"	"	0.04175	"
1.10	1	0.04025	0.0405	0.04075	0.04075	0.0405	0.041	0.0406
	2	"	"	0.041	0.041	0.04075	0.0405	0.0407
	3	"	0.040	0.04025	0.0405	0.0405	0.041	0.0404
1.11	1	0.04275	0.04275	0.04175	0.03975	0.03925	0.04075	0.0411
	2	0.0425	0.0425	0.0415	0.0395	0.0395	0.04025	0.0410
	3	0.04225	0.04225	0.04125	0.03925	0.03925	0.04025	0.0408
1.12	1	0.0395	0.0395	0.0415	0.043	0.043	0.041	0.0413
	2	0.040	0.040	0.04075	"	0.04275	"	"
	3	0.03925	"	0.0405	"	0.043	0.04075	0.0411
1.13	1	0.0405	0.041	0.0405	0.03975	0.040	0.04075	0.0404
	2	0.041	0.042	0.041	0.0395	0.039	0.040	0.0404
1.14	1	0.043	0.04175	0.039	0.03925	0.041	0.04275	0.0411
1.15	1	0.040	0.0395	0.04025	0.043	0.043	0.042	0.0413
1.16	1	0.04075	0.0395	0.03975	0.0415	0.04275	0.0425	0.0411
1.17	1	0.042	0.0425	0.0425	0.041	0.03925	0.03925	0.0411
1.18	1	0.04025	0.039	0.040	0.0425	0.043	0.04225	0.0412

APPENDIX IE (Contd)

Variation in Wall Thickness for 1" Dia. × 20 S.W.G. × T45 Steel Tubes Showing Relation Between Wall Thickness and Collapse Pattern. Set 2

Tube No.	Station	A	B	C	D	E	F	Mean
2.3	1	0.040	0.0405	0.0405	0.042	0.04175	0.04075	0.0409
	2	0.0405	0.040	0.0405	"	0.042	0.041	0.041
	3	0.04025	0.03975	0.0405	0.0415	0.0415	"	0.0408
	4	0.040	0.040	0.0405	"	"	0.04075	0.0407
	5	"	0.03925	0.040	0.041	0.04125	0.04075	0.0404
	6	0.04025	"	"	"	0.0415	0.0405	0.0404
	7	0.040	0.03975	"	"	0.04175	0.0405	0.0405
2.4	1	0.03975	0.0405	0.0415	0.04175	0.0405	0.040	0.0407
	2	"	0.04075	"	"	"	"	"
	3	"	0.0405	"	"	"	"	"
	4	0.0395	0.0405	"	0.0415	0.04025	"	0.0405
	5	0.03975	0.040	0.041	"	0.0405	"	"
	6	0.0395	0.0405	0.0415	0.0405	"	0.03475	0.0404
2.5	1	0.042	0.041	0.0395	0.03925	0.040	0.041	0.0405
	2	0.0415	"	"	0.0395	"	"	0.0404
	3	0.04175	"	"	"	"	"	0.0405
	4	0.0415	"	"	0.039	"	0.04125	0.0404
	5	0.0415	0.04075	"	0.0395	"	0.041	"
	6	0.042	0.041	"	"	0.03975	0.04075	"
2.6	1	0.040	0.039	0.040	0.041	0.04225	0.0415	0.0406
	2	"	"	0.0395	"	"	"	0.0405
	3	"	0.0385	0.03925	"	"	"	0.0404
	4	"	0.03875	0.03975	"	0.0425	"	0.0406
	5	"	0.039	0.03975	"	0.042	"	0.0405
2.7	1	0.040	0.0395	0.039	0.041	0.042	0.042	0.0406
	2	0.04025	"	0.03925	"	0.04175	0.04175	0.0406
	3	0.0405	"	"	0.0405	0.0415	"	0.0405
	4	0.040	"	"	"	0.042	0.0415	0.0405
	5	"	0.03975	0.039	0.04025	0.04225	0.04175	0.0405
2.8	1	0.03975	0.03975	0.04025	0.0415	0.04175	0.0405	0.0406
	2	0.03975	0.0395	"	"	0.0415	"	0.0405
	3	0.040	0.040	"	"	0.04175	"	0.0407
	4	0.03975	"	"	"	0.042	0.04075	"
2.9	1	0.0405	0.04175	0.042	0.04075	0.03925	0.0395	0.0406
	2	0.04025	0.042	0.0425	0.041	"	0.03925	0.0407
	3	0.04025	0.04175	0.04225	0.04075	0.039	0.039	0.0405
	4	0.0405	0.042	0.04225	"	0.03925	0.0395	0.0407
2.10	1	0.0405	0.041	0.041	0.0405	0.040	0.040	0.0405
	2	0.040	0.0405	0.0405	0.04075	"	"	0.0403
	3	0.04025	0.04075	0.040	0.040	"	"	0.0402
2.11	1	0.03975	0.04025	0.04225	0.042	0.04075	0.0395	0.0407
	2	0.03875	"	0.042	0.04175	0.041	"	0.0405
	3	0.039	"	"	0.042	0.0405	0.03975	0.0406
2.12	1	0.0415	0.040	0.040	0.040	0.041	0.042	0.0407
	2	0.04125	0.04025	0.03975	0.03975	0.04075	0.04175	0.0406
	3	"	"	0.040	"	0.041	0.04175	0.0407
2.13	1	0.040	0.041	0.0405	0.040	0.040	0.04075	0.0404
	2	"	0.040	0.040	"	0.04025	0.0405	0.0401
2.14	1	0.0415	0.04175	0.0405	0.03925	0.0395	0.040	0.0404
2.15	1	0.03875	0.04025	0.041	0.04225	0.0415	0.3925	0.0405
2.16	1	0.0405	0.039	0.039	0.0405	0.04175	0.042	0.0405
2.17	1	0.03975	0.0395	0.03975	0.04125	0.042	0.041	0.0405
2.18	1	0.040	0.04025	0.041	0.041	0.04025	0.0395	0.0403
2.19	1	0.03975	0.03975	0.040	0.04075	0.0415	0.041	0.0405

Variation in Wall Thickness for 1" Dia. × 20 S.W.G. × T45 Steel Tubes Showing Relation Between Wall Thickness and Collapse Pattern. Set 3

Tube No.	Station	A	B	C	D	E	F	Mean
3.1	1	0.04175	0.042	0.04075	0.040	0.03975	0.04075	0.0408
	2	0.04225	0.0415	0.04025	0.03975	0.0395	"	"
	3	0.042	"	0.041	0.040	0.03975	0.0405	0.0410
	4	"	0.04175	0.04075	0.03975	"	0.04075	"
	5	"	"	0.040	0.03925	"	0.0415	0.0409
	6	"	0.042	"	0.0395	"	"	0.0408
	7	0.04225	0.04175	0.04025	"	0.040	0.041	"
	8	"	0.0415	0.040	"	0.0395	"	0.0407
3.2	1	0.040	0.04025	0.0415	0.04175	0.0405	0.040	0.0407
	2	0.03975	0.040	0.04175	0.0415	0.04025	0.03975	0.0405
	3	"	"	0.04125	0.04175	"	0.0395	0.0404
	4	0.0395	0.04025	0.0415	0.0415	0.040	0.0395	0.0404
	5	0.040	"	0.04075	"	0.04025	"	0.0402
	6	"	"	0.0415	"	0.0405	0.03925	0.0405
	7	0.0395	0.040	0.04125	"	0.0405	"	0.0403
3.3	1	0.04225	0.0415	0.040	0.040	0.03975	0.04125	0.0411
	2	0.042	"	0.04025	0.03925	"	"	0.0407
	3	"	"	0.040	"	"	"	0.0406
	4	0.0415	0.041	0.0395	"	"	0.041	0.0403
	5	0.04175	0.0415	0.040	"	"	0.04125	0.0406
	6	0.042	"	"	"	"	0.041	"
	7	0.04125	0.04125	0.03975	"	0.040	0.0395	0.0407
3.4	1	0.04075	0.042	0.04225	0.0415	0.0405	0.040	0.0412
	2	0.04125	"	"	0.04125	0.04075	"	0.0413
	3	0.041	"	"	"	0.04025	"	0.0411
	4	"	0.0415	"	"	"	"	0.0410
	5	0.04075	"	0.042	0.041	0.0395	0.03925	0.0407
	6	"	0.04125	0.04225	0.04125	0.040	0.0395	0.0408
	7	0.041	0.042	0.042	"	0.040	"	0.0410
3.5	1	0.0415	0.04225	0.0415	0.04025	0.0395	0.040	0.0408
	2	"	"	"	0.040	"	"	"
	3	0.04125	"	0.04175	0.04025	0.03925	"	"
	4	"	0.042	0.04125	0.040	"	"	0.0406
	5	0.0415	0.04225	0.04175	0.04025	"	0.03975	0.0408
	6	0.04125	"	0.0415	0.040	"	0.040	0.0407
3.6	1	0.0425	0.042	0.04125	0.040	0.0395	0.04075	0.041
	2	0.04175	"	0.041	0.03975	"	"	0.0408
	3	0.042	"	"	0.040	"	"	0.0409
	4	0.04225	0.04225	"	"	"	"	0.0410
	5	0.0415	0.042	0.04075	0.03975	"	0.04125	"
3.7	1	0.040	0.0405	0.04125	0.04175	0.04125	0.0405	0.0409
	2	"	"	"	"	"	"	"
	3	0.03975	"	"	0.042	0.0415	"	"
	4	0.040	0.04075	0.04075	0.04175	0.04125	"	0.0408
	5	"	"	0.04125	0.04225	0.0415	"	0.0410

Tube No.	Station	A	B	C	D	E	F	Mean
3.8	1	0.04225	0.04075	0.040	0.04025	0.04025	0.041	0.0409
	2	"	"	0.03975	0.040	"	0.04125	0.0407
	3	0.0425	0.041	0.040	"	0.041	"	0.0410
	4	0.04225	0.04075	0.03975	"	"	0.042	0.0410
3.9	1	0.04075	0.040	0.03975	0.041	0.042	0.0415	0.0408
	2	"	0.03975	0.0395	"	0.0425	0.04175	0.0407
	3	0.041	"	"	"	"	"	0.0409
	4	0.040	0.040	0.03975	0.040	0.04225	0.0415	0.0406
3.10	1	0.040	0.04075	0.04025	0.04025	0.040	0.040	0.0402
	2	"	"	0.0405	0.04075	"	0.03975	0.0403
	3	"	"	0.04075	0.0405	"	0.040	"
3.11	1	0.04125	0.040	0.0395	0.040	0.04125	0.0415	0.0406
	2	"	"	0.03925	0.03975	"	"	"
	3	0.04175	"	"	0.040	0.0415	0.042	0.0407
3.12	1	0.0405	0.042	0.04225	0.0405	0.03925	0.03925	0.0406
	2	"	"	"	0.04075	0.0395	0.039	0.0407
	3	"	0.04225	0.04225	0.041	0.03925	0.03925	0.0409
3.13	1	0.0395	0.0405	0.04075	0.041	0.04025	0.03975	0.0408
	2	"	0.04025	"	"	0.040	0.0395	0.0402
3.14	1	0.04025	0.03975	0.040	0.041	0.04175	0.0415	0.0407
3.15	1	0.04075	0.0395	0.04025	0.0415	0.04175	0.041	0.0408
3.16	1	0.0405	0.04025	0.03975	0.041	0.04175	0.04175	0.0408
3.17	1	0.04175	0.0405	0.0395	0.0395	0.041	0.042	0.0407
3.18	1	0.0405	0.03975	0.03975	0.04125	0.04175	0.0415	0.0407

APPENDIX IE (Contd)

Variation from True Circular Form of 1" Dia. × 20 S.W.G. × T45 Steel Tubes. Set 1

Tube No.	Degree of Ovality
1	Maximum 0.0925 over whole length
2	" 0.00225 " " "
3	" 0.00175 " " "
4	" 0.00225 " " "
5	" 0.002 " " "
6	" 0.0015 " " "
7	" 0.00175 " " "
8	" 0.00225 " " "
9	" 0.0015 " " "
10	" 0.00200 " " "
11	" 0.00175 " " "

Variation from True Circular Form of 1" Dia. × 20 S.W.G. × T45 Steel Tubes. Set 2

Tube No.	Degree of Ovality
3	Under 0.002 over full length
4	" 0.002 " " "
5	" 0.0025 " " "
6	" 0.0015 " " "
7	Maximum 0.002 " " "
8	Under 0.0015 " " "
9	" 0.0015 " " "
10	" 0.002 " " "
11	" 0.002 " " "
12	" 0.0015 " " "
13	Maximum 0.004 " " "
14	" 0.002 " " "
15	" 0.002 " " "
16	" 0.0015 " " "
17	" 0.0015 " " "
18	" 0.002 " " "

APPENDIX IE (Contd)

Variation from True Circular Form of 1" Dia. × 20 S.W.G. × T45 Steel Tubes. Set 3

Tube No.	Degree of Ovality
1	Maximum 0.0025 over whole length
2	" 0.001 " " "
3	" 0.0025 " " "
4	" 0.0022 " " "
5	" 0.002 " " "
6	" 0.0015 " " "
7	" 0.005 " " "
8	" 0.0015 " " "
9	Under 0.002 " " "
10	" 0.002 " " "
11	" 0.0015 " " "
12	" 0.002 " " "
13	" 0.002 " " "
14	" 0.002 " " "
15	" 0.0015 " " "
16	" 0.0015 " " "
17	" 0.001 " " "

APPENDIX IE (Contd)

Mechanical Properties of 1" Dia. × 20 S.W.G. × T45 Steel Tubes

Tube No.	Direction of Grain	E × 10^{-6}	L.P.	0.1% P.S.	0.2% P.S.	0.5% P.S.	Max. Stress	Elong. % on 1"
1	L	28.4	22.6	44.7	45.6	46.2	47.7	11.0
	T	30.7	7.73	44.3	48.3	51.2	51.8	4.0
2	L	29.6	23.4	48.6	48.8	49.2	50.4	11.0
	T	28.6	15.1	49.5	51.9	53.7	53.7	3.0
3	L	28.7	21.9	44.8	45.3	45.7	47.7	10.0
	T	29.4	12.3	43.7	46.4	48.4	50.8	4.0

Relation between Mechanical Test and Actual Test Specimens for 1" Dia. × 20 S.W.G. × T45 Steel Tubes

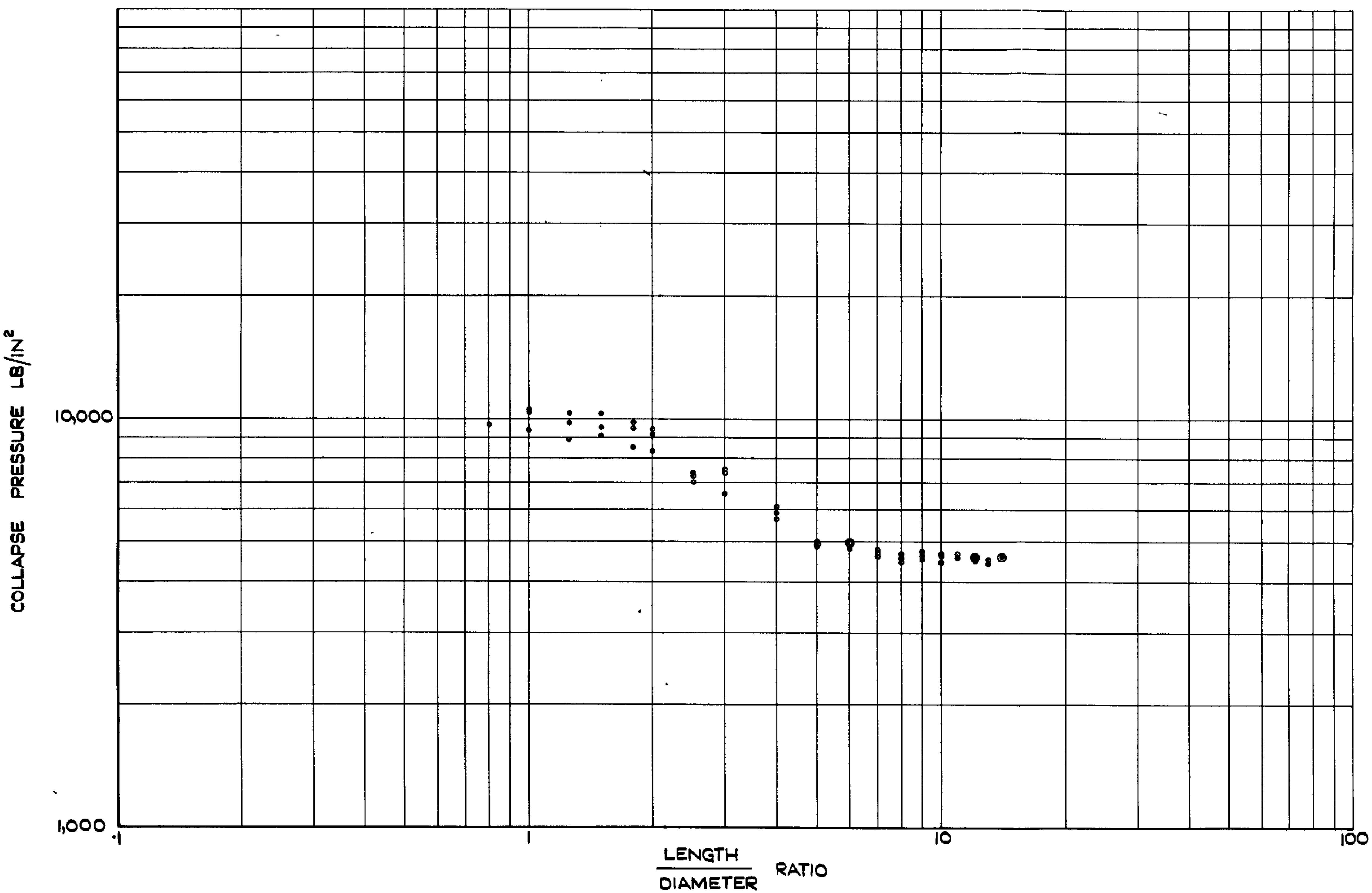
Mechanical Test Specimen	Actual Test Specimen Sets
1 3	1) 3) less tubes 1.13, 3.13, 1.10, 3.10
2	2 and tubes 1.10, 3.10, 1.13, 3.13

Results of Tests on 1" Dia. × 20 S.W.G. × T45 Steel Tubes under Uniform External Pressure Applied to the Sides Only

Tube No.	Corrected Collapse Pressure	L/D	Actual No. Lobes Formed	No. Lobes in Complete Periphery
1.1	4575	14	2	2
2.1	-	-	-	-
3.1	4575	14	2	2
1.2	4425	13	2	2
2.2	-	-		
3.2	4500	13	2	2
1.3	4575	12	2	2
2.3	4525	12	2	2
3.3	4525	12	2	2
1.4	4565	11	2	2
2.4	4565	11	2	2
3.4	4675	11	2	2
1.5	4675	10	2	2
2.5	4475	10	2	2
3.5	4625	10	2	2
1.6	4655	9	2	2
2.6	4565	9	2	2
3.6	4715	9	2	2
1.7	4675	8	2	2
2.7	4565	8	2	2
3.7	4500	8	2	2
1.8	4725	7	2	2
2.8	4675	7	2	2
3.8	4775	7	2	2
1.9	4925	6	2	2
2.9	4925	6	2	2
3.9	4825	6	2	2
1.10	4875	5	2	2
2.10	4950	5	2	2
3.10	4925	5	2	2
1.11	5905	4	2	2
2.11	5700	4	2	2
3.11	6100	4	2	2
1.12	7400	3	2	2
2.12	6600	3	2	2
3.12	7500	3	2	2
1.13	7300	2.5	3	3
2.13	7000	2.5	3	3
3.13	7400	2.5	2	2

APPENDIX IE (Contd)

Tube No.	Corrected Collapse Pressure	L/D	Actual No. Lobes Formed	No. of Lobes in Complete Periphery
1.14	9450	2	3	4
2.14	9200	2		
3.14	8400	2	3	3
1.15	9800	1.8	4	4
2.15	9500	1.8	3	3
3.15	8550	1.8	4	4
1.16	10300	1.5	4	4
2.16	9600	1.5	4	4
3.16	9100	1.5	4	4
1.17	10300	1.25	4	4
2.17	9800	1.25	2	4
3.17	8950	1.25	4	4
1.18	10600	1.00	4	4
2.18	10500	1.00	4	4
3.18	9400	1.00	4	4
2.19	9750	0.8	2	5



GRAPHICAL PRESENTATION OF RESULTS OF TESTS ON 1" DIA. × 20 S.W.G. × T. 45 STEEL TUBES UNDER UNIFORM EXTERNAL PRESSURE ON THE SIDES ONLY.

APPENDIX IF

Variation in wall thickness for 1" dia. × 17 S.W.G. × T45 Steel Tubes showing relation between wall thickness and collapse pattern. Set I

Tube No.	Station	A	B	C	D	E	F	Mean
1.1	1	0.05875	0.0595	0.059	0.05825	0.05775	0.058	0.0585
	2	"	"	"	0.0585	0.05825	"	0.0587
	3	"	"	0.05925	0.05825	0.05775	0.05775	0.0585
	4	0.0585	0.059	0.059	0.0585	0.0585	0.05825	0.0586
	5	0.058	"	0.0595	0.0595	0.05825	0.058	0.0587
	6	0.05825	0.0595	"	"	0.0585	0.05775	0.059
	7	0.05875	0.05925	0.05975	0.05975	"	0.0575	0.0588
1.2	1	0.05975	0.0575	0.056	0.0575	0.06025	0.06125	0.0587
	2	0.06025	0.058	0.05575	0.057	0.060	0.0615	0.0587
	3	"	0.058	0.056	"	"	0.06125	"
	4	0.060	0.05825	0.0565	0.05725	0.0595	0.06075	0.0587
	5	"	0.0585	0.057	"	0.059	0.060	0.0586
	6	0.05975	0.059	0.0575	0.0575	"	"	0.0588
	7	0.060	0.05925	"	"	0.05875	0.05975	0.0588
1.3	1	0.055	0.05525	0.059	0.0625	0.062	0.05825	0.0587
	2	0.05525	"	"	"	"	0.059	0.0588
	3	0.0555	"	"	0.06225	"	0.05875	0.0588
	4	0.05575	"	0.05875	0.062	"	0.059	"
	5	0.05625	"	0.0585	0.06125	"	0.057	0.0584
	6	0.057	"	0.058	0.06175	"	0.058	0.0587
1.4	1	0.06075	0.06425	0.06075	0.0565	0.0545	0.056	0.0588
	2	0.060	0.06325	0.06025	0.05625	"	"	0.0584
	3	"	0.063	0.06125	0.05675	"	0.0555	0.0586
	4	"	"	0.06125	0.0575	0.05475	"	0.0587
	5	0.05925	"	0.06125	0.05725	0.055	0.05575	"
1.5	1	0.05475	0.0585	0.0625	0.063	0.05925	0.05525	0.0588
	2	0.0545	0.05825	0.06275	0.06325	"	0.05475	0.0588
	3	0.054	0.058	"	"	0.0595	"	0.0587
	4	0.0545	0.05825	0.0625	"	0.05925	"	"
1.6	1	0.0635	0.060	0.055	0.05425	0.0575	0.062	0.0587
	2	"	"	0.0555	"	"	"	0.0588
	3	"	"	"	0.054	0.05725	0.06225	0.0587
1.7	1	0.0605	0.0555	0.054	0.0565	0.061	0.0635	0.05850
	2	0.0605	0.0555	"	0.057	0.06175	0.06375	0.0587
	3	0.0605	0.05575	"	0.05675	0.0615	"	0.0587
1.8	1	0.054	0.0555	0.0605	0.0635	0.062	0.0575	0.0588
1.9	1	0.0575	0.0535	0.055	0.060	0.064	0.06225	0.0587
1.10	1	0.05375	0.05475	0.05925	0.064	0.063	0.05775	0.0588

APPENDIX IF (Contd)

Variation in wall thickness for 1" dia. x 17 S.W.G. x T45 Steel Tubes showing relation between wall thickness and collapse pattern. Set II

Tube No.	Station	A	B	C	D	E	F	Mean
2.1	1	0.05875	0.05725	0.057	0.05825	0.060	0.060	0.0585
	2	0.05825	"	0.05725	0.05875	"	0.060	0.0586
	3	0.05875	0.0575	0.057	0.058	0.0595	0.0595	0.0584
	4	0.059	0.05725	0.0565	0.0575	"	0.060	0.0583
	5	0.05925	0.058	0.057	0.05725	0.05875	0.0595	0.0583
	6	0.0595	0.05775	0.0565	0.0575	0.0595	0.06025	0.05850
	7	0.05975	"	0.05675	0.05725	0.05925	0.06025	0.05850
	8	0.060	0.05825	0.05625	0.057	0.059	0.060	0.0584
2.2	1	0.05625	0.05675	0.05875	0.06025	0.05975	0.0575	0.0582
	2	0.0555	0.0565	0.059	0.0605	0.05975	0.05725	0.0581
	3	0.05525	0.05575	"	0.06075	0.06025	"	0.0580
	4	0.0555	0.0555	0.05825	0.06025	0.060	0.0575	0.0578
	5	0.05525	"	0.0585	0.061	0.0605	0.058	0.0581
	6	0.05575	0.05575	0.05825	"	0.061	0.0585	0.0584
	7	0.0555	0.05525	0.05775	0.0605	0.06125	"	0.0581
2.3	1	0.0565	0.054	0.056	0.060	0.063	0.0605	0.0583
	2	0.05675	0.05425	"	0.06025	"	0.061	0.0585
	3	0.057	0.05425	"	"	"	0.06125	0.0586
	4	0.05725	0.05475	0.05625	"	0.06275	"	0.0587
	5	0.05775	0.055	0.05575	0.060	"	"	0.0588
	6	0.0575	0.05475	0.05575	0.05975	0.0625	"	0.0586
2.4	1	0.05725	0.06125	0.06275	0.0595	0.05525	0.05425	0.0584
	2	0.0575	0.0615	0.063	0.060	"	"	0.0586
	3	0.05775	0.06125	0.06275	"	0.0555	0.0545	0.0586
	4	0.057	0.062	0.0625	"	0.055	"	0.0585
	5	"	0.061	"	0.05925	"	0.05425	0.0582
2.5	1	0.06025	0.0625	0.060	0.057	0.0545	0.0565	0.0585
	2	0.060	"	0.06125	0.05725	"	0.05625	0.0586
	3	"	0.06275	0.0615	"	"	0.056	0.0587
	4	"	"	"	0.0575	"	"	0.0587
2.6	1	0.061	0.0565	0.05475	0.05675	0.0605	0.063	0.0587
	2	"	0.057	0.05425	0.056	0.06075	"	0.0587
	3	"	0.0565	0.054	0.05625	0.0605	0.0625	0.0584
2.7	1	0.062	0.059	0.0555	0.05525	0.05825	0.0615	0.0586
	2	"	"	0.05525	"	"	0.06175	0.0586
	3	0.06175	0.0585	0.05475	0.05475	0.058	0.0615	0.0582
2.8	1	0.05725	0.061	0.06175	0.0595	0.05575	0.05475	0.0583
2.9	1	0.0555	0.05825	0.06125	0.06125	0.05875	0.05625	0.0585
2.10	1	0.0615	0.05975	0.05675	0.0555	0.0575	0.06025	0.0585
2.11	1	0.06125	0.0605	0.05825	0.056	0.0565	0.05925	0.0586

APPENDIX IF (Contd)

Variation in wall thickness for 1" dia. × 17 S.W.G. × T45 Steel Tubes Showing relation between wall thickness and collapse pattern. Set III

Tube No.	Station	A	B	C	D	E	F	Mean
3.1	1	0.0585	0.057	0.0565	0.0585	0.060	0.06025	0.0586
	2	"	"	0.05675	0.05825	"	"	"
	3	0.05875	0.0575	0.057	0.0585	"	0.060	0.0586
	4	0.0585	0.05725	0.05675	"	0.0595	0.05975	0.0584
	5	0.060	0.0575	0.0575	"	"	0.0595	0.0588
	6	"	"	"	"	"	0.05975	"
	7	0.0585	0.0585	0.0585	0.05875	"	0.05925	0.0588
3.2	1	0.0585	0.058	0.0585	0.059	0.05875	0.0585	0.0585
	2	"	0.0585	0.05875	0.05875	0.0585	"	0.0586
	3	"	0.05825	0.0585	0.059	0.059	0.059	0.0587
	4	"	0.059	0.059	0.0585	0.058	0.058	0.0585
	5	"	0.05925	0.0595	0.059	0.0585	0.0585	0.0589
	6	0.059	0.060	"	"	0.05825	0.058	0.0590
	7	0.0585	0.0595	"	"	0.05775	0.0585	0.0588
3.3	1	0.0615	0.06075	0.058	0.056	0.05675	0.0595	0.0588
	2	0.061	0.060	0.05775	0.05625	0.05725	"	0.0586
	3	0.0605	0.06025	0.05825	"	0.057	0.05925	0.0586
	4	0.06075	0.060	"	0.0565	0.05725	0.0595	0.0587
	5	0.0605	0.06025	0.0585	"	"	0.05925	"
	6	0.060	0.060	"	0.05675	0.0570	0.0585	0.0586
3.4	1	0.0560	0.063	0.064	0.06125	0.0545	0.053	0.0586
	2	0.0555	0.062	0.06425	"	0.0555	0.0525	0.05850
	3	0.05525	0.0615	"	0.061	"	0.05275	0.0584
	4	0.0555	"	"	0.06175	0.0565	0.05325	0.0588
	5	"	"	0.064	0.0615	0.056	0.053	0.0586
	6	"	0.062	0.064	0.061	0.05625	0.05325	0.0587
3.5	1	0.061	0.055	0.0535	0.057	0.0615	0.064	0.0587
	2	0.061	0.055	"	"	0.06175	"	0.0587
	3	0.062	0.05575	0.053	0.0565	0.0615	0.06425	0.0588
	4	0.06075	0.05525	0.05325	0.05625	0.06175	0.064	0.0585
	5	0.06125	0.05575	"	0.05675	0.06025	"	0.0585
3.6	1	0.0625	0.064	0.06025	0.0555	0.0535	0.0565	0.0587
	2	"	"	0.061	0.056	0.05375	0.057	0.0590
	3	0.062	0.06375	0.06025	0.05525	0.05425	"	0.0586
3.7	1	0.0595	0.05475	0.054	0.058	0.0625	0.06325	0.0587
	2	"	0.055	"	"	"	0.0635	0.0587
	3	0.060	"	0.05375	"	0.063	0.06325	0.0588
3.8	1	0.05925	0.06325	0.06325	0.059	0.05425	0.05425	0.0589
3.9	1	0.054	0.056	0.0605	0.0635	0.06225	0.05725	0.0589
3.10	1	0.05675	0.05675	0.05875	0.06075	0.061	0.059	0.0588

APPENDIX IF (Contd)

Ovality of 1" Dia. × 17 S.W.G. × T45 Steel Tubes. Set I

Tube No.	Ovality
1	Approximately 0.0015 over whole length
2	" 0.0015 " " "
3	" 0.0015 " " "
4	" 0.001 " " "
5	" 0.0015 " " "
6	" 0.001 " " "
7	" 0.001 " " "
8	" 0.001 " " "
9	" 0.001 " " "
10	" 0.001 " " "

Ovality of 1" Dia. × 17 S.W.G. × T45 Steel Tubes. Set II

Tube No.	Ovality
1	Under 0.0015 over whole length
2	Approximately 0.001 " " "
3	" 0.0015 " " "
4	" 0.001 " " "
5	" 0.005 " " "
6	" 0.002 " " "
7	" 0.0015 " " "
8	" 0.001 " " "
9	" 0.0015 " " "
10	" 0.001 " " "
11	" 0.001 " " "

Ovality of 1" Dia. × 17 S.W.G. × T45 Steel Tubes. Set III

Tube No.	Ovality
1	Approximately 0.0015 over whole length
2	Under 0.002 " " "
3	" 0.002 " " "
4	" 0.0015 " " "
5	" 0.0015 " " "
6	" 0.0015 " " "
7	" 0.001 " " "
8	" 0.001 " " "
9	Approximately 0.001 " " "
10	" 0.0065 " " "

APPENDIX IF (Contd)

Mechanical Properties of 1" Dia. × 17 S.W.G. × T45 Steel Tubes

Tube No.	Direction of Grain	LP	0.1% PS	0.2% PS	0.5% PS	Max. Stress	Elongation % on 1"	$E \times 10^{-6}$
1	L	26.8	44.7	45.2	46.1	51.3	14.0	31.6
	T	8.9	40.1	42.4	44.7	53	3.0	27.7
2	L	18.5	39.7	40.2	41.1	44.3	17.0	30.6
	T	11.5	47.1	49.9	52.3	52.7	5.0	28.3

Relation between Material Test and Pressure Test Specimens

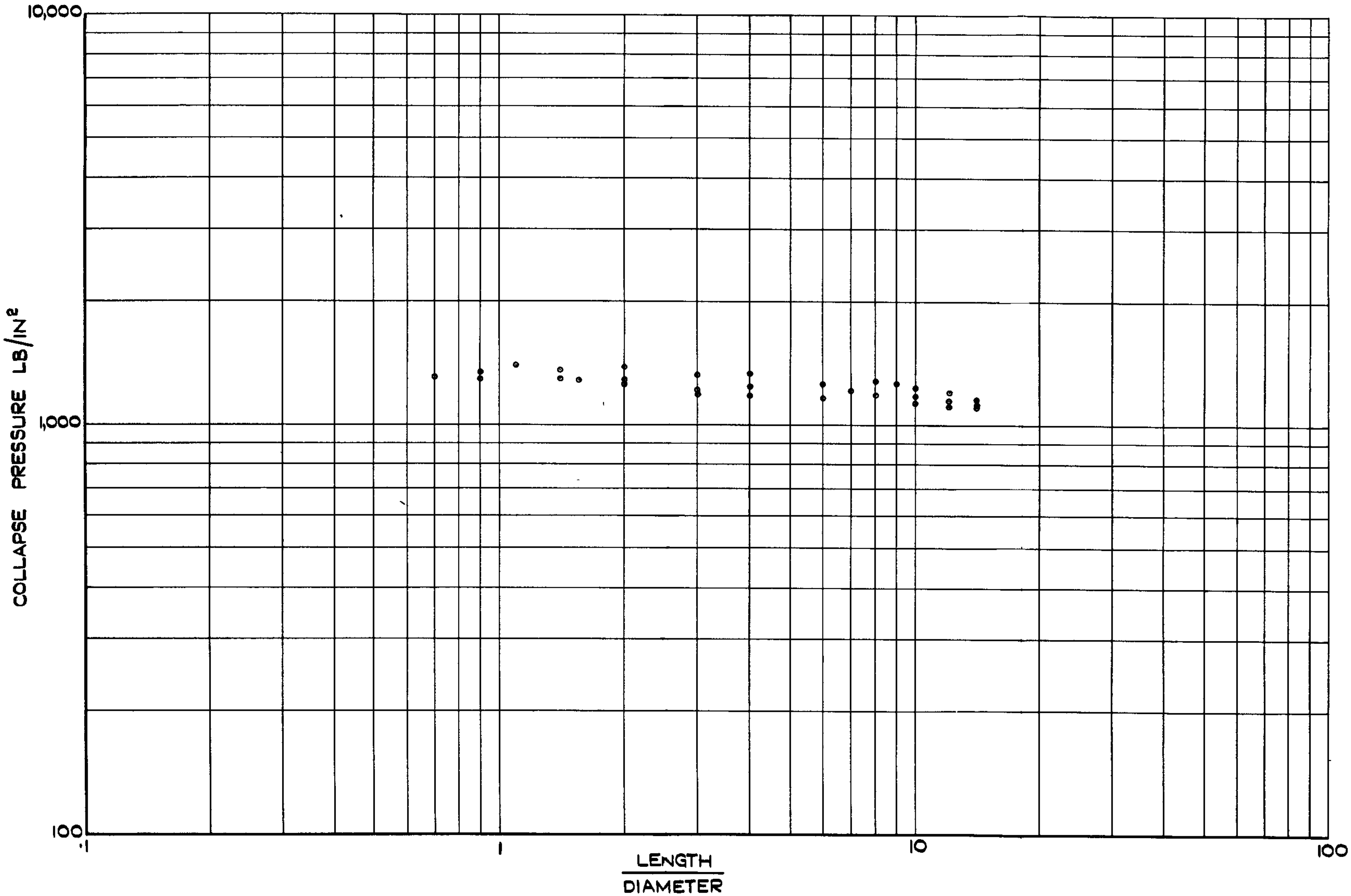
Mechanical Test Specimen	Pressure Test Specimen Sets
1	1 also tubes 3.4,3.5,3.6,3.7,3.8,3.9
2	2 also tubes 3.1, 3.2, 3.3, 3.10

APPENDIX IF (Contd)

Results of Tests on 1" Dia. × 17 S.W.G. × T45 Steel Tubes under Uniform External Pressure Applied to the Sides only

Tube No.	Collapse Pressure	$\frac{L}{D}$	No. Lobes formed	Estimated No. Lobes in Complete Periphery
1.1	11300	14	2	2
2.1	11200	"	"	"
3.1	11600	"	"	"
1.2	12000	12	"	"
2.2	11200	"	"	"
3.2	11500	"	"	"
1.3	12300	10	"	"
2.3	11400	"	"	"
3.3	11750	"	"	"
1.4	12800	8	"	"
2.4	11800	"	"	"
3.4	12600	9	"	"
1.5	12500	6	"	"
2.5	11700	"	"	"
3.5	12100	7	"	"
1.6	13400	4	"	"
2.6	11800	"	"	"
3.6	12400	"	"	"
1.7	13250	3	"	"
2.7	11950	"	"	"
3.7	12200	"	"	"
1.8	13900	2	"	"
2.8	12600	"	3	3
3.8	12750	"	2	2
1.9	13650	1.4	"	"
2.9	13000	1.4	3	3
3.9	12900	1.55	2	2
1.10	13500	0.9	2	2
2.10	13000	0.9	3	3
3.10	14000	1.1	"	"
2.11	13200	0.7	2	2

Attached: Drg. S.M.E. 75082/R



RESULTS OF TESTS ON 1" DIA. x 17 S.W.G. x T45 STEEL TUBES UNDER UNIFORM EXTERNAL PRESSURE APPLIED TO THE SIDES ONLY.

APPENDIX IG

Variations of Tube Thickness for 1" dia x 24 S.W.G. x D.T.D.305 steel tubes showing relation between wall thickness and collapse pattern - set I

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.0210	0.0215	0.0240	0.026	0.026	0.0230	0.0236
	2	0.0215	0.022	0.025	0.027	0.026	0.023	0.0241
	3	0.0215	0.0215	0.024	0.026	0.0255	0.023	0.0236
	4	0.021	0.021	0.023	0.025	0.026	0.0235	0.0231
	5	0.0215	0.021	0.0235	0.026	0.026	0.0235	0.0236
	6	0.022	0.0215	0.0235	0.026	0.0255	0.023	0.0236
	7	0.022	0.022	0.024	0.026	0.026	0.0235	0.0239
	8	0.022	0.0215	0.023	0.0255	0.026	0.0235	0.0236
2	1	0.022	0.022	0.023	0.0255	0.026	0.0245	0.0238
	2	0.022	0.0215	0.023	0.025	0.026	0.0240	0.0236
	3	0.022	0.0215	0.023	0.025	0.026	0.0245	0.0237
3	1	0.0235	0.022	0.0225	0.0245	0.026	0.0260	0.0241
	2	0.0235	0.022	0.022	0.024	0.026	0.0260	0.0239
4	1	0.0235	0.022	0.022	0.024	0.026	0.026	0.0239
	2	0.0235	0.0215	0.022	0.024	0.026	0.0255	0.0238
5	1	0.025	0.026	0.0245	0.022	0.021	0.0225	0.0235
	2	0.025	0.026	0.025	0.022	0.021	0.0225	0.0236
6	1	0.024	0.0265	0.026	0.023	0.0215	0.0215	0.0238
7	1	0.0215	0.0240	0.026	0.026	0.0235	0.0210	0.0237
8	11	0.025	0.026	0.0245	0.0225	0.0215	0.023	0.0238
9	1	0.023	0.025	0.026	0.024	0.022	0.021	0.0225
10	1	0.025	0.026	0.0245	0.022	0.0215	0.0235	0.0238
11	1	0.021	0.021	0.0235	0.026	0.026	0.024	0.0236
12	1	0.023	0.025	0.026	0.025	0.0225	0.022	0.0239

APPENDIX IG (Contd)

Variations of Tube Thickness for 1" dia. × 24 S.W.G. × D.T.D.305 steel tubes showing relation between wall thickness and collapse pattern - set II

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.0220	0.0240	0.0265	0.0255	0.0230	0.0215	0.0238
	2	0.0215	0.0240	0.0265	0.0250	0.0235	0.0215	0.0236
	3	0.0220	0.0245	0.0265	0.0255	0.0230	0.0215	0.0238
	4	0.0220	0.0240	0.0265	0.0255	0.0230	0.0215	0.0237
	5	0.0220	0.0240	0.0260	0.0250	0.0235	0.0220	0.0239
	6	0.0220	0.0245	0.0260	0.0255	0.0230	0.0215	0.0238
	7	0.0225	0.0245	0.0260	0.0260	0.0235	0.0215	0.0243
	8	0.0220	0.0245	0.0265	0.0255	0.0230	0.0215	0.0238
2	1	0.0255	0.0230	0.0215	0.0225	0.0245	0.0265	0.0239
	2	0.0255	0.0230	0.0215	0.0220	0.0245	0.0265	0.0238
	3	0.0260	0.0230	0.0215	0.0220	0.0240	0.0260	0.0238
3	1	0.0260	0.0270	0.0250	0.0220	0.0215	0.0230	0.0241
	2	0.0255	0.0265	0.0240	0.0225	0.0215	0.0230	0.0238
4	1	0.0245	0.0220	0.0215	0.0230	0.0260	0.0265	0.0239
	2	0.0245	0.0220	0.0215	0.0230	0.0260	0.0265	0.0239
5	1	0.0245	0.0220	0.0210	0.0230	0.0260	0.0265	0.0238
	2	0.0250	0.0220	0.0210	0.0230	0.0265	0.0265	0.0239
6	1	0.0210	0.0220	0.0250	0.0265	0.0250	0.0225	0.0236
7	1	0.0245	0.0265	0.0260	0.0235	0.0220	0.0220	0.0241
8	1	0.0255	0.0230	0.0220	0.0225	0.0250	0.0265	0.0241
9	1	0.0220	0.0250	0.0270	0.0260	0.0230	0.0210	0.0240
10	1	0.0230	0.0215	0.0225	0.0250	0.0265	0.0250	0.0238
11	1	0.0260	0.0255	0.0235	0.0215	0.0230	0.0240	0.0239
12	1	0.0240	0.0260	0.0260	0.0240	0.0220	0.0220	0.0240

APPENDIX IG (Contd)

Variations of Tube Thickness for 1" dia. x 24 S.W.G. x D.T.D.305 steel tubes showing relation between wall thickness and collapse pattern - set III

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.0235	0.0245	0.0255	0.0245	0.0230	0.0230	0.024
	2	0.0235	0.0245	0.0255	0.0245	0.0225	0.0220	0.0238
	3	0.023	0.025	0.026	0.025	0.023	0.023	0.0241
	4	0.023	0.025	0.026	0.025	0.0225	0.022	0.0243
	5	0.023	0.0245	0.0255	0.025	0.023	0.022	0.0238
	6	0.023	0.025	0.026	0.025	0.023	0.022	0.024
	7	0.023	0.025	0.0265	0.0255	0.023	0.022	0.0241
	8	0.023	0.0245	0.0265	0.0255	0.023	0.022	0.0241
2	1	0.025	0.024	0.023	0.0225	0.0235	0.025	0.0238
	2	0.025	0.024	0.023	0.0225	0.024	0.025	0.0239
	3	0.025	0.024	0.023	0.0225	0.024	0.025	0.0239
3	1	0.025	0.0255	0.024	0.023	0.0225	0.024	0.024
	2	0.025	0.025	0.0235	0.023	0.023	0.024	0.0239
4	1	0.023	0.0245	0.026	0.0255	0.024	0.0225	0.0243
	2	0.023	0.0245	0.026	0.025	0.0235	0.0225	0.0241
5	1	0.0245	0.0255	0.0250	0.0235	0.0225	0.0230	0.024
	2	0.0245	0.0255	0.0250	0.0235	0.0225	0.0230	0.024
6	1	0.0230	0.0230	0.0250	0.0260	0.0250	0.0240	0.0243
7	1	0.0250	0.0265	0.0260	0.0230	0.0215	0.0225	0.0241
8	1	0.0245	0.0260	0.0250	0.0235	0.0225	0.0230	0.0241
9	1	0.0260	0.0250	0.0240	0.0230	0.0230	0.0250	0.0243
10	1	0.0225	0.0230	0.0240	0.0255	0.0250	0.0235	0.0239
11	1	0.0250	0.0245	0.0230	0.0220	0.0235	0.0250	0.0238
12	1	0.0250	0.0245	0.0235	0.0225	0.0230	0.0240	0.0238

APPENDIX IG (Contd)

Ovality of 1" Dia. x 24 S.W.G. x D.T.D.305 Steel Tubing as Deviation from Nominal Diameter - Set I

Tube No.	Station	Maximum	Position	Minimum	Position
1	1	+0.003	C-F	-0.0005	B-E
	2	+0.004	A-D	-0.0005	B-E
	3	+0.002	A-D	Nil	B-E
	4	+0.0015	A-D	Nil	B-E
	5	+0.003	C-F	Nil	B-E
	6	+0.0025	A-D	-0.001	C-F
	7	+0.009	A-D	-0.013	C-F
	8	+0.011	A-D	-0.011	C-F
2	1	+0.003	A-D	-0.002	C-F
	2	+0.003	A-D	-0.002	B-E
	3	+0.002	C-F	Nil	B-E
3	1	+0.002	A-D	Nil	B-E
	2	+0.0025	A-D	-0.0005	C-F
4	1	+0.003	A-D	-0.0005	B-E
	2	+0.003	A-D	-0.001	B-E
5	1	+0.004	C-F	-0.002	B-E
	2	+0.005	C-F	-0.0015	A-D
6	1	+0.0045	A-D	-0.0015	B-E
7	1	+0.004	B-E	-0.0005	C-F
8	1	+0.002	B-E	+0.001	A-D
9	1	+0.003	A-D	Nil	B-E
10	1	+0.0025	C-F	+0.0005	A-D
11	1	+0.0065	A-D	-0.001	C-F

APPENDIX IG (Contd)

Ovality of 1" Dia. x 24 S.W.G. x D.T.D.305 Steel Tubing as Deviation from Nominal Diameter - Set II

Tube No.	Station	Maximum	Position	Minimum	Position
1	1	+0.0045	B-E	-0.0015	A-D
	2	+0.005	A-D	-0.0005	C-F
	3	+0.003	B-E	Nil	C-F
	4	+0.0025	B-E	Nil	C-F
	5	+0.0025	B-E	+0.0005	C-F
	6	+0.0025	B-E	+0.0005	A-D
	7	+0.0025	B-E	+0.001	A-D
	8	+0.005	B-E	+0.0015	C-F
2	1	+0.003	B-E	-0.0005	A-D
	2	+0.005	C-F	-0.0015	A-D
	3	+0.003	B-E	-0.001	A-D
3	1	+0.003	C-F	Nil	A-D
	2	+0.002	C-F	+0.0005	A-D
4	1	+0.0035	A-D	Nil	B-E
	2	+0.005	A-D	-0.002	B-E
5	1	+0.002	B-E	+0.001	F-C
	2	+0.003	A-D	-0.002	F-C
6	1	+0.004	B-E	-0.001	A-D
7	1	+0.006	B-E	-0.001	A-D
8	1	+0.006	A-D	-0.002	B-E
9	1	+0.007	B-E	-0.002	F-C
10	1	+0.005	B-E	-0.001	F-C
11	1	+0.002	F-C	Nil	B-E

APPENDIX IG (Contd)

Ovality of 1" Dia. x 24 S.W.G. x D.T.D.305 Steel Tubing as Deviation from Nominal Diameter - Set III

Tube No.	Station	Maximum	Position	Minimum	Position
1	1	+0.002	B-E	Nil	A-D
	2	+0.0015	C-F	+0.001	B-E
	3	+0.0015	A-D	+0.0005	B-E
	4	+0.002	B-E	+0.0005	A-D
	5	+0.002	B-E	+0.001	A-D
	6	+0.002	B-E	Nil	C-F
	7	+0.002	A-D	+0.0005	C-F
	8	+0.002	B-E	Nil	C-F
2	1	+0.0015	B-E	Nil	A-D
	2	+0.002	A-D	Nil	B-E
	3	+0.001	-	+0.001	-
3	1	+0.002	B-E	Nil	A-D
	2	+0.002	C-F	+0.001	A-D
4	1	+0.002	C-F	+0.0005	A-D
	2	+0.002	C-F	+0.001	B-E
5	1	+0.002	A-D	+0.001	B-E
	2	+0.002	C-F	+0.001	B-E
6	1	+0.003	C-F	+0.0005	B-E
7	1	+0.003	A-D	Nil	C-F
8	1	+0.0025	C-F	+0.001	B-E
9	1	+0.003	C-F	+0.001	A-D
10	1	+0.002	B-E	+0.001	A-D
11	1	+0.0025	B-E	+0.001	F-C

APPENDIX IG (Contd)

Mechanical Properties of 1" Dia. x 24 S.W.G. x D.T.D.305 Steel Tubing

Tube No.	Direction of Grain	E x 10^{-6}	L.P.	0.1% P.S.	0.2% P.S.	0.5% P.S.	Max. Stress	Elong. % on 1"
1	L	29.0	21.8	34.8	35.2	35.7	36.1	5.0
	T	29.6	11.6	34.6	36.1	36.9	37.0	1.0

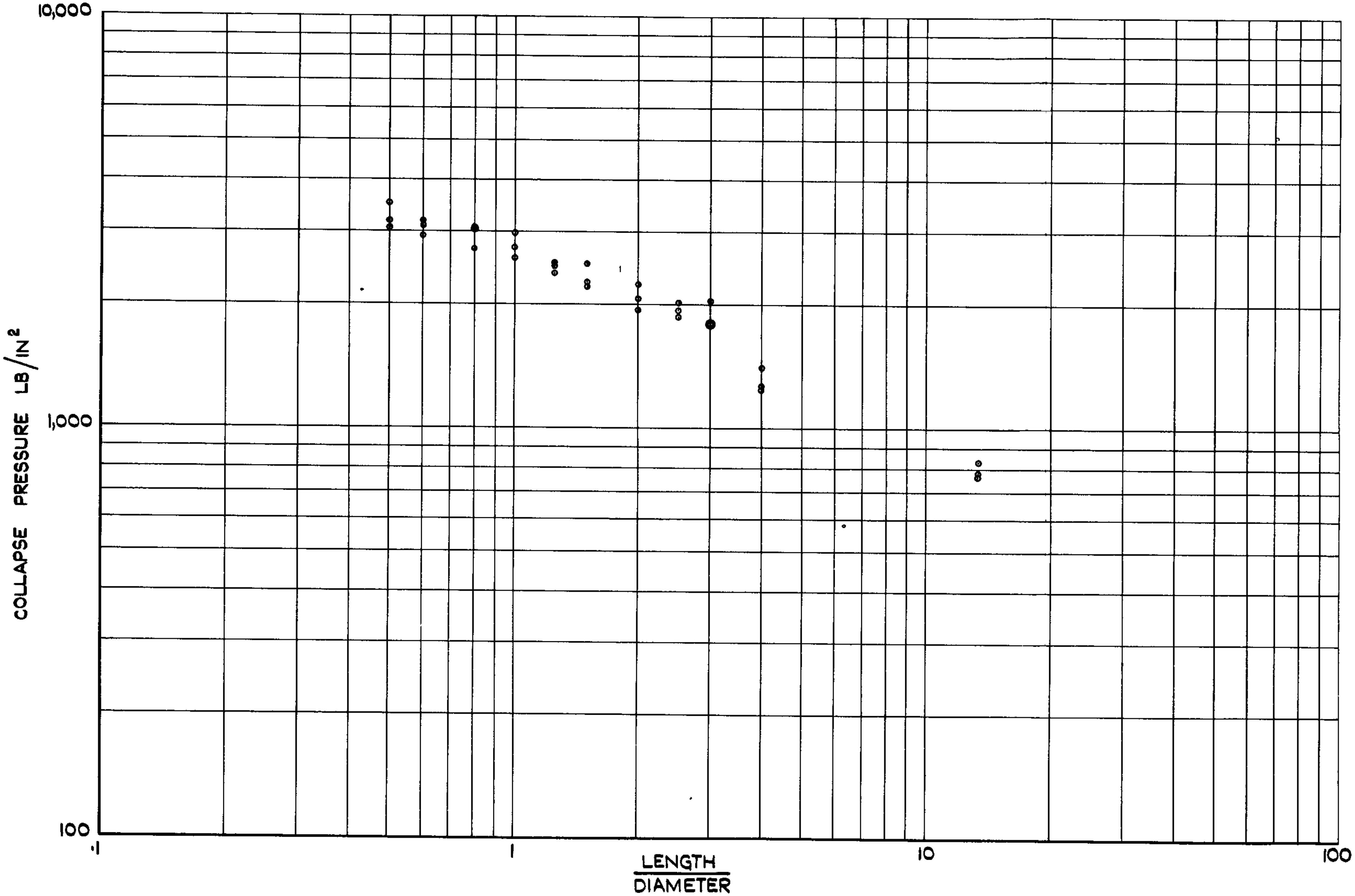
Relation between Mechanical and Pressure Test Specimens

Since all pressure test specimens were cut from one length of tube, the results quoted above were applied in all cases.

APPENDIX IG (Contd)

Results of Tests on 1" Dia. x 24 S.W.G. x D.T.D.305 Steel Tubing under Uniform External Pressure Applied to the Sides Only

Tube No.	Pressure	$\frac{L}{D}$	No. Lobes formed	No. Lobes in Complete Periphery
1.1	760	14	2	2
2.1	780		2	2
3.1	830		2	2
1.2	1230	4	2	2
2.2	1250		2	2
3.2	1410		2	2
1.3	1800	3	2	2
2.3	1790		2	2
3.3	2040		3	3
1.4	1920	2.5	2	2
2.4	1860		2	2
3.4	2000		3	3
1.5	1940	2.0	2	4
2.5	2060		2	4
3.5	2230		2	4
1.6	2200	1.5	3	5
2.6	2260		3	4
3.6	2500		4	4
1.7	2470	1.25	3	5
2.7	2375		2	4
3.7	2500		2	4
1.8	2730	1.0	2	5
2.8	2625		3	6
3.8	2920		2	5
1.9	3050	0.8	2	5
2.9	2700		1	5
3.9	3030		2	5
1.10	3180	0.6	1	6
2.10	2920		1	6
3.10	3100		1	6
1.11	3050	0.5	1	6
2.11	3250		1	6
3.11	3180		1	6



RESULTS OF TESTS ON 1" DIA. X 24 S.W.G. X D.T.D. 305 STEEL TUBE UNDER UNIFORM EXTERNAL PRESSURE APPLIED TO THE SIDES ONLY.

TABLE II

Collapse coefficients for Round Cylinders with Pressure
Applied to the Sides Only, Ends Simply Supported

$D/t = 100$

L/R	N = 2	N = 3	N = 4	N = 5	N = 6	N = 7
40	2.23					
20	2.48					
16	2.87					
15	3.04					
12	4.19					
10	6.21	6.29				
9	8.20	6.49				
8		6.80				
7		7.36				
6		8.45				
5		10.86				
4.8			12.53			
4.5		13.19	12.88			
4.0			13.73			
3.5			15.26			
3.0			18.13			
2.9						
2.8						
2.7			21.16	21.81		
2.6				22.31		
2.5			24.17	22.9		
2.4				23.61		
2.3						
2.2				25.42		
2.1						
2.0				28.09		
1.9				29.9		
1.8				32.14		
1.7				34.96	35.16	
1.6				43.15	36.93	
1.5					39.19	
1.4					42.13	
1.3					46.03	
1.2					51.27	52.19
1.1					58.47	56.6
1.0						62.8
0.95						
0.90						71.79
0.85						
0.80						
0.75						
0.70						
0.65						
0.60						

APPENDIX IH (Contd)

Variation of Wall Thickness of 1" Dia x 24 S.W.G. x T55 Steel Tubes showing relation between Wall Thickness and Collapse Pattern - Set 2

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.0235	0.0245	0.027	0.0275	0.0265	0.024	0.0255
	2	0.0235	0.026	0.0275	0.028	0.0265	0.024	0.0259
	3	0.023	0.0255	0.0265	0.0275	0.0275	0.024	0.0257
	4	0.0235	0.025	0.0265	0.027	0.026	0.024	0.0253
	5	0.023	0.025	0.0265	0.027	0.0265	0.024	0.0253
	6	0.023	0.025	0.0265	0.027	0.0265	0.024	0.0253
	7	0.023	0.025	0.0265	0.0275	0.026	0.0235	0.02525
	8	0.0235	0.025	0.0265	0.028	0.027	0.024	0.0257
2	1	0.025	0.026	0.027	0.026	0.024	0.023	0.0251
	2	0.0245	0.0265	0.0275	0.0265	0.024	0.023	0.0253
	3	0.025	0.0265	0.028	0.0265	0.024	0.023	0.0255
3	1	0.026	0.0275	0.0265	0.0245	0.023	0.024	0.0252
	2	0.026	0.0275	0.0265	0.024	0.023	0.024	0.0251
4	1	0.024	0.026	0.0275	0.027	0.0245	0.023	0.0253
	2	0.024	0.026	0.028	0.0275	0.025	0.023	0.0256
5	1	0.023	0.0235	0.026	0.028	0.0265	0.025	0.0253
	2	0.0235	0.024	0.026	0.028	0.0265	0.025	0.0255
6	1	0.024	0.0265	0.0275	0.0265	0.025	0.024	0.0256
7	1	0.026	0.027	0.028	0.026	0.024	0.023	0.0257
8	1	0.0265	0.028	0.0265	0.024	0.0235	0.025	0.0257
9	1	0.027	0.025	0.023	0.024	0.026	0.027	0.0253
10	1	0.023	0.025	0.026	0.0275	0.0265	0.024	0.0253
11	1	0.026	0.025	0.0235	0.0235	0.0255	0.0275	0.0251
12	1	0.026	0.024	0.0235	0.025	0.0255	0.027	0.0251
13	1	0.024	0.0255	0.027	0.026	0.024	0.023	0.0249

Variation of Wall Thickness of 1" Dia x T55 Steel Tubes showing relation between Wall Thickness and Collapse Pattern - Set 3

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.027	0.0265	0.025	0.0235	0.023	0.025	0.0251
	2	0.0265	0.0265	0.026	0.024	0.023	0.025	0.0257
	3	0.026	0.0265	0.0255	0.024	0.023	0.025	0.025
	4	0.0265	0.027	0.026	0.025	0.023	0.0245	0.0253
	5	0.027	0.0265	0.0255	0.025	0.023	0.025	0.0253
	6	0.027	0.027	0.026	0.025	0.023	0.0255	0.0256
	7	0.026	0.027	0.0265	0.0245	0.023	0.0255	0.0254
	8	0.0265	0.027	0.026	0.0245	0.023	0.024	0.0251
2	1	0.026	0.0245	0.023	0.023	0.0255	0.0265	0.0247
	2	0.026	0.024	0.0235	0.024	0.0255	0.027	0.025
	3	0.026	0.024	0.023	0.0235	0.0255	0.027	0.0248
3	1	0.0225	0.024	0.0265	0.027	0.0265	0.024	0.0251
	2	0.0225	0.024	0.026	0.027	0.0265	0.024	0.025
4	1	0.024	0.0235	0.0245	0.0255	0.026	0.025	0.0247
	2	0.024	0.023	0.025	0.026	0.0265	0.025	0.0249
5	1	0.0265	0.0265	0.0255	0.023	0.024	0.025	0.0251
	2	0.0265	0.026	0.025	0.024	0.0245	0.025	0.0251
6	1	0.0235	0.0245	0.027	0.027	0.026	0.0245	0.0254
7	1	0.0265	0.026	0.0245	0.0235	0.024	0.026	0.0251
8	1	0.025	0.024	0.024	0.024	0.025	0.026	0.0247
9	1	0.027	0.026	0.024	0.023	0.0245	0.0255	0.025
10	1	0.0265	0.027	0.0255	0.024	0.024	0.025	0.0253

APPENDIX IH (Contd)

Ovality of 1" Dia x 24 S.W.G. x T55 Steel Tubes as Deviation from Nominal Diameter - Set I

Tube No.	Station	Maximum	Position	Minimum	Position
1	1	+003	A-D	-001	B-E
	2	+005	A-D	+001	C-F
	3	+0035	C-F	+003	A-D
	4	+0045	A-D	+002	B-E
	5	+0055	A-D	+001	C-F
	6	+007	A-D	-0015	B-E
	7	+0045	C-F	+002	B-E
	8	+005	C-F	+002	B-E
2	1	+006	A-D	-001	C-F
	2	+007	A-D	-001	C-F
	3	+007	B-E	-001	C-F
3	1	+006	B-E	-001	A-D
	2	+007	C-F	Nil	A-D
4	1	+005	F-C	Nil	E-B
	2	+004	A-D	+002	F-C
5	1	+004	F-C	+001	B-E
	2	+005	E-B	Nil	F-C
6	1	+006	A-D	-001	F-C
7	1	+004	E-B	+002	A-D
8	1	+005	A-D	Nil	F-C
9	1	+004	F-C	+002	B-E
10	1	+004	A-D	Nil	F-C
11	1	+005	F-C	+002	B-E
12	1	+005	F-C	Nil	A-D
13	1	+005	A-D	+001	F-C

APPENDIX IH (Contd)

Ovality of 1" Dia x 24 S.W.G. x T55 Steel Tubes as Deviation from Nominal Diameter - Set 2

Tube No.	Station	Maximum	Position	Minimum	Position
1	1	+003	A-D	-001	B-E
	2	+005	A-D	+001	C-F
	3	+0035	C-F	+003	A-D
	4	+0045	A-D	+002	B-E
	5	+0055	A-D	+001	C-F
	6	+007	A-D	-0015	B-E
	7	+0045	C-F	+002	B-E
	8	+005	C-F	+002	B-E
2	1	+006	A-D	-001	C-F
	2	+007	A-D	-001	C-F
	3	+007	B-E	-001	C-F
3	1	+006	B-E	-001	A-D
	2	+007	F-C	Nil	A-D
4	1	+005	F-C	Nil	E-B
	2	+004	A-D	+002	F-C
5	1	+004	F-C	+001	B-E
	2	+005	E-B	Nil	F-C
6	1	+006	A-D	-001	F-C
7	1	+004	B-E	+002	A-D
8	1	+005	A-D	Nil	F-C
9	1	+004	F-C	+002	B-E
10	1	+004	A-D	Nil	F-C
11	1	+005	F-C	+002	B-E
12	1	+005	F-C	Nil	A-D
13	1	+005	A-D	+001	F-C

APPENDIX IH (Contd)

Ovality of 1" Dia x 24 S.W.G. x T55 Steel Tubes as Deviation from Nominal Diameter - Set 3

Tube No.	Station	Maximum	Position	Minimum	Position
1	1	+0045	C-F	+002	B-E
	2	+005	C-F	+002	B-E
	3	+0045	A-D	+001	C-F
	4	+005	C-F	+0015	B-E
	5	+006	C-F	Nil	B-E
	6	+005	A-D	+0015	B-E
	7	+006	A-D	+001	C-F
	8	+007	C-F	Nil	B-E
2	1	+005	B-E	-0025	C-F
	2	+006	C-F	-002	A-D
	3	+006	B-E	+001	C-F
3	1	+003	A-D	+0015	B-E
	2	+006	C-F	+001	B-E
4	1	+0065	A-D	-003	B-E
	2	+006	A-D	Nil	B-E
5	1	+004	B-E	+001	C-F
	2	+004	A-D	Nil	C-F
6	1	+005	C-F	+001	A-D
7	1	+011	B-E	-0015	C-F
8	1	+004	A-D	-001	B-E
9	1	+005	C-F	-005	B-E
10	1	+002	A-D	-003	B-E

APPENDIX IH (Contd)

Mechanical Properties of 1" Dia x 24 S.W.G. x T55 Steel Tubing

Specimen No.	Direction of Grain	E x 10^{-6}	L.P.	0.1% P.S.	0.2% P.S.	0.5% P.S.	Maximum Stress	Elongation %
1	L T	28.0 28.5	8.4 6.0	17.7 20.8	19.8 23.7	22.5 27.4	48.5 44.3	37.0 25.0

Relation between Mechanical and Pressure Test Specimens

Since all pressure test specimens were cut from one length of tube, the results quoted above were applied in all cases.

APPENDIX IH (Contd)

Results of Tests on 1" Dia x 24 S.W.G. x T55 Steel Tubes under Uniform External pressure applied to the sides only

Tube No.	Collapse Pressure	L/D	No. Lobes Formed	Estimated No. Lobes in Complete Periphery
1.1	800	14	2	2
2.1	740	14	2	2
3.1	800	14	2	2
1.2	1150	4.0	2	2
2.2	1250	4.0	2	2
3.2	1140	4.0	2	2
1.3	1520	3.0	3	3
2.3	1520	3.0	3	3
3.3	1310	3.0	2	3
1.4	1640	2.5	3	3
2.4	1500	2.5	3	3
3.4	1750	2.5	3	3
1.5	1740	2.0	3	3
2.5	1720	2.0	3	3
3.5	1860	2.0	3	3
1.6	1970	1.5	4	4
2.6	1920	1.5	4	4
3.6	2300	1.5	3	3
1.7	2270	1.2	4	4
2.7	2000	1.2	3	4
3.7	2240	1.25	4	4
1.8	2270	1.0	4	4
2.8	2150	1.0	3	5
3.8	2300	1.0	4	4
1.9	2680	0.8	4	4
2.9	2180	0.6	4	4
3.9	2400	0.6	3	5
1.10	3000	0.6	4	5
2.10	2500	0.5	5	5
1.11	3480	0.5	4	6
2.11	4100	0.45	5	5
1.12	4000	0.4	5	5
2.12	4200	0.4	4	6

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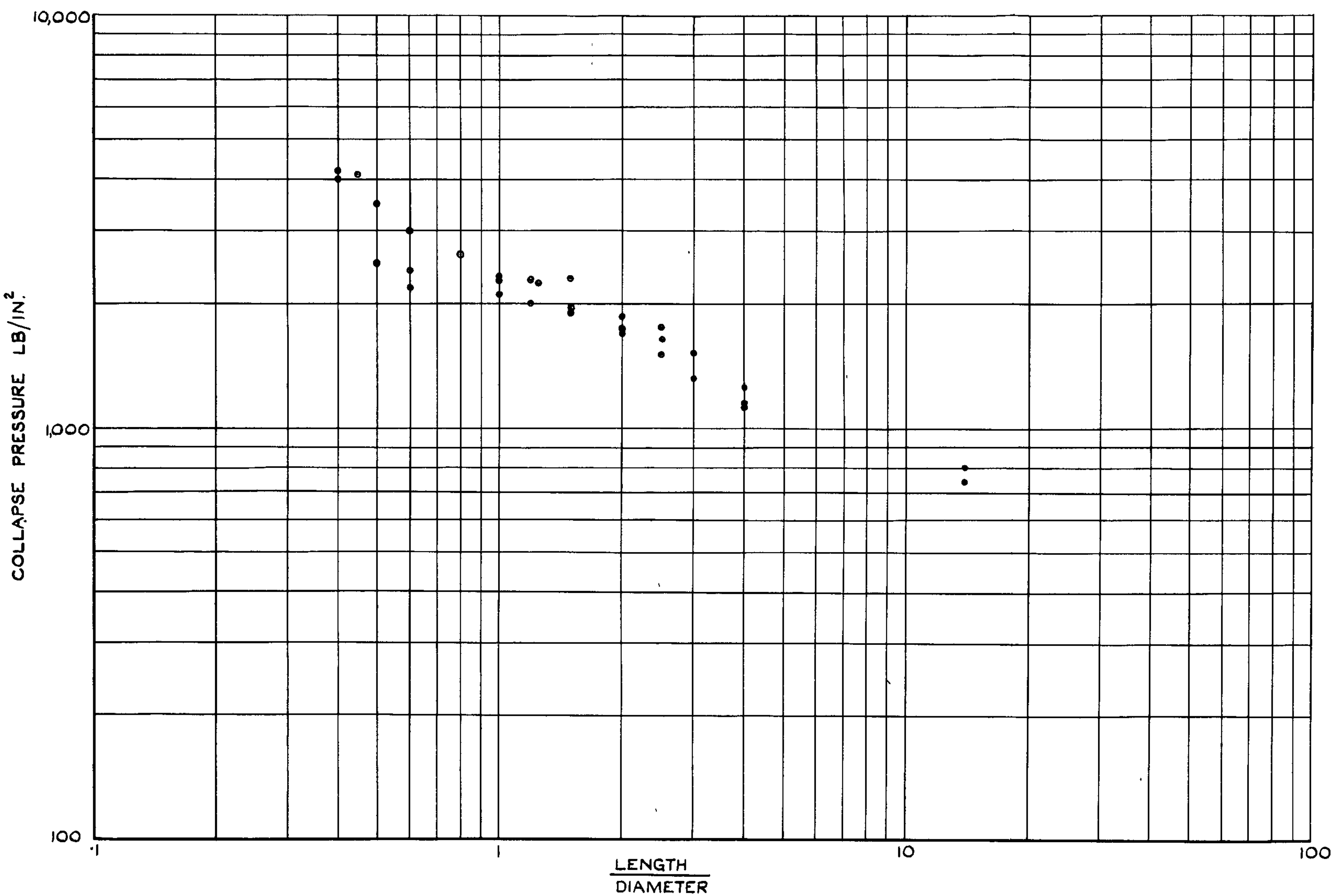


RESULTS OF TESTS ON 1" DIA. X 24 S.W.G. X T55 STEEL TUBES
UNDER UNIFORM EXTERNAL PRESSURE APPLIED TO THE SIDES ONLY.

APPENDIX LJ

Variations of Tube Thickness for 1" dia. x 24 S.W.G. x T26 Steel Tubes Showing Relation Between Wall Thickness and Collapse Pattern - Set I

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.0235	0.0240	0.0240	0.0240	0.0235	0.0230	0.0237
	2	0.0240	0.0240	0.0245	0.0240	0.0235	0.0235	0.0239
	3	0.0240	0.0240	0.0240	0.0240	0.0235	0.0235	0.0238
	4	0.0235	0.0240	0.0240	0.0235	0.0235	0.0230	0.0236
	5	0.0240	0.0240	0.0240	0.0240	0.0235	0.0235	0.0238
	6	0.0235	0.0240	0.0240	0.0235	0.0235	0.0235	0.0236
	7	0.0235	0.0240	0.0240	0.0240	0.0235	0.0235	0.0238
	8	0.0235	0.0240	0.0240	0.0240	0.0235	0.0235	0.0238
2	1	0.0230	0.0230	0.0235	0.0240	0.0240	0.0235	0.0235
	2	0.0235	0.0235	0.0240	0.0240	0.0240	0.0235	0.0238
	3	0.0230	0.0235	0.0235	0.0240	0.0240	0.0235	0.0236
3	1	0.0235	0.0240	0.0240	0.0235	0.0230	0.0230	0.0235
	2	0.0235	0.0240	0.0235	0.0230	0.0230	0.0230	0.0233
4	1	0.0230	0.0230	0.0235	0.0240	0.0235	0.0230	0.0233
	2	0.0230	0.0230	0.0235	0.0240	0.0235	0.0230	0.0233
5	1	0.0230	0.0230	0.0235	0.0240	0.0240	0.0235	0.0235
	2	0.0230	0.0230	0.0235	0.0240	0.0235	0.0235	0.0234
6	1	0.0230	0.0230	0.0235	0.0235	0.0235	0.0230	0.0233
7	1	0.0230	0.0230	0.0235	0.0235	0.0230	0.0230	0.0232
8	1	0.0230	0.0230	0.0230	0.0235	0.0235	0.0235	0.0233
9	1	0.0230	0.0235	0.0235	0.0235	0.0230	0.0230	0.0233
10	1	0.0230	0.0230	0.0230	0.0235	0.0235	0.0235	0.0233
11	1	0.0235	0.0235	0.0235	0.0230	0.0230	0.0230	0.0233
12	1	0.0230	0.0235	0.0240	0.0235	0.0230	0.0230	0.0233

APPENDIX LJ (Contd)

Variations of Tube Thickness for 1" dia. x 24 S.W.G. x T26 Steel Tubes Showing Relation Between Wall Thickness and Collapse Pattern - Set II

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.0230	0.0230	0.0230	0.0225	0.0225	0.0230	0.0228
	2	0.0235	0.0230	0.0230	0.0225	0.0225	0.0230	0.0228
	3	0.0230	0.0230	0.0230	0.0225	0.0225	0.0230	0.0228
	4	0.0230	0.0230	0.0230	0.0225	0.0225	0.0230	0.0228
	5	0.0235	0.0230	0.0230	0.0230	0.0225	0.0235	0.0231
	6	0.0235	0.0230	0.0230	0.0225	0.0225	0.0230	0.0229
	7	0.0235	0.0230	0.0230	0.0230	0.0230	0.0235	0.0232
	8	0.0235	0.0230	0.0230	0.0230	0.0225	0.0235	0.0229
2	1	0.0225	0.0230	0.0235	0.0230	0.0230	0.0230	0.0230
	2	0.0225	0.0230	0.0235	0.0230	0.0230	0.0230	0.0230
	3	0.0230	0.0235	0.0235	0.0235	0.0230	0.0230	0.0233
3	1	0.0230	0.0235	0.0235	0.0230	0.0230	0.0230	0.0232
	2	0.0230	0.0235	0.0235	0.0230	0.0230	0.0230	0.0232
4	1	0.0230	0.0235	0.0235	0.0235	0.0230	0.0230	0.0233
	2	0.0230	0.0230	0.0235	0.0235	0.0235	0.0230	0.0233
5	1	0.0225	0.0230	0.0230	0.0235	0.0235	0.0230	0.0231
	2	0.0225	0.0230	0.0230	0.0235	0.0235	0.0230	0.0231
6	1	0.0230	0.0230	0.0235	0.0235	0.0230	0.0230	0.0232
7	1	0.0230	0.0235	0.0235	0.0235	0.0230	0.0230	0.0233
8	1	0.0235	0.0235	0.0230	0.0230	0.0230	0.0230	0.0232
9	1	0.0230	0.0225	0.0230	0.0235	0.0235	0.0230	0.0231
10	1	0.0235	0.0230	0.0230	0.0235	0.0235	0.0235	0.0233
11	1	0.0240	0.0235	0.0225	0.0230	0.0230	0.0235	0.0233
12	1	0.0235	0.0235	0.0235	0.0230	0.0230	0.0230	0.0233

APPENDIX IJ (Contd)

Variations of Tube Thickness for 1" dia. x 24 S.W.G. x T26 Steel Tubes
Showing Relation Between Wall Thickness and Collapse Pattern - Set III

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.0235	0.0230	0.0230	0.0235	0.0235	0.0235	0.0233
	2	0.0230	0.0230	0.0235	0.0240	0.0230	0.0230	0.0233
	3	0.0230	0.0230	0.0230	0.0240	0.0230	0.0235	0.0233
	4	0.0230	0.0230	0.0230	0.0235	0.0235	0.0230	0.0232
	5	0.0230	0.0230	0.0235	0.0235	0.0235	0.0230	0.0233
	6	0.0230	0.0230	0.0230	0.0230	0.0230	0.0230	0.0230
	7	0.0235	0.0230	0.0230	0.0230	0.0230	0.0230	0.0231
	8	0.0230	0.0230	0.0235	0.0230	0.0230	0.0230	0.0231
2	1	0.0235	0.0235	0.0230	0.0230	0.0230	0.0230	0.0232
	2	0.0235	0.0230	0.0230	0.0230	0.0230	0.0230	0.0231
	3	0.0235	0.0235	0.0230	0.0230	0.0230	0.0230	0.0232
3	1	0.0230	0.0230	0.0235	0.0235	0.0235	0.0230	0.0233
	2	0.0230	0.0230	0.0230	0.0230	0.0235	0.0235	0.0232
4	1	0.0230	0.0230	0.0230	0.0235	0.0235	0.0230	0.0232
	2	0.0230	0.0230	0.0230	0.0230	0.0235	0.0230	0.0231
5	1	0.0230	0.0230	0.0235	0.0235	0.0235	0.0235	0.0233
	2	0.0230	0.0225	0.0230	0.0235	0.0235	0.0235	0.0232
6	1	0.0230	0.0235	0.0235	0.0235	0.0230	0.0230	0.0233
7	1	0.0235	0.0235	0.0230	0.0230	0.0235	0.0235	0.0233
8	1	0.0230	0.0230	0.0225	0.0230	0.0235	0.0235	0.0231
9	1	0.0230	0.0230	0.0230	0.0235	0.0235	0.0230	0.0232
10	1	0.0230	0.0230	0.0230	0.0235	0.0235	0.0230	0.0232
11	1	0.0235	0.0235	0.0230	0.0230	0.0230	0.0230	0.0232
12	1	0.0230	0.0230	0.0235	0.0235	0.0230	0.0230	0.0232

APPENDIX LJ (Contd)

Ovality of 1" dia. x 24 S.W.G. x T26 Steel Tubing - Set I

Tube No.	Station	Maximum	Position	Minimum	Position
1	1	+0.002	B-E	-0.001	A-D
	2	+0.0015	"	-0.0005	"
	3	+0.001	"	Nil	C-F
	4	+0.002	C-F	-0.0005	B-E
	5	+0.003	"	-0.002	"
	6	+0.001	B-E	Nil	A-D
	7	+0.0005	-	+0.0005	-
	8	+0.0005	-	+0.0015	-
2	1	+0.002	C-F	-0.001	B-E
	2	+0.008	A-D	-0.004	"
	3	+0.001	C-F	-0.001	A-D
3	1	+0.001	C-F	Nil	A-D
	2	+0.003	"	-0.0015	"
4	1	+0.004	A-D	-0.0015	B-E
	2	+0.0045	B-E	-0.0025	F-C
5	1	+0.002	F-C	Nil	A-D
	2	+0.004	"	-0.0015	"
6	1	+0.002	A-D	+0.0005	E-B
7	1	+0.0035	A-D	-0.0015	F-C
8	1	+0.006	B-E	-0.002	A-D
9	1	+0.003	A-D	-0.001	F-C
10	1	+0.007	B-E	-0.003	A-D
11	1	+0.002	B-E	-0.0005	F-C
12	1	+0.005	A-D	-0.005	F-C

APPENDIX LJ (Contd)

Ovality of 1" dia. x 24 S.W.G. x T26 Steel Tubing - Set II

Tube No.	Station	Maximum	Position	Minimum	Position
1	1	+0.002	B-E	Nil	A-D
	2	+0.003	"	-0.002	F-C
	3	+0.002	"	-0.0005	"
	4	+0.0015	"	-0.0005	A-D
	5	+0.0015	C-F	Nil	"
	6	+0.0015	B-E	-0.0005	F-C
	7	+0.001	A-D	Nil	"
	8	+0.0015	C-F	-0.0005	B-E
2	1	+0.002	A-D	Nil	C-F
	2	+0.0015	B-E	-0.001	"
	3	+0.0025	"	-0.002	"
3	1	+0.0015	C-F	Nil	B-E
	2	+0.004	A-D	-0.003	C-F
4	1	+0.0005	A-D	-0.0005	B-E
	2	+0.002	"	Nil	C-F
5	1	+0.003	C-F	Nil	B-E
	2	+0.0015	"	+0.001	A-D
6	1	+0.003	B-E	Nil	F-C
7	1	+0.002	B-E	+0.0015	A-D
8	1	+0.0025	C-F	+0.0005	B-E
9	1	+0.0015	-	+0.0015	-
10	1	+0.0025	C-F	+0.001	B-E
11	1	+0.0015	-	+0.0015	-
12	1	+0.001	-	+0.001	-

APPENDIX LJ (Contd)

Ovality of 1" dia. x 24 S.W.G. x T26 Steel Tubing - Set III

Tube No.	Station	Maximum	Position	Minimum	Position
1	1	+0.0015	C-F	-0.0005	A-D
	2	+0.001	B-E	Nil	A-D
	3	+0.0015	C-F	Nil	B-E
	4	+0.0015	B-E	-0.001	A-D
	5	+0.002	"	-0.001	"
	6	+0.002	"	-0.001	"
	7	+0.0015	"	Nil	"
	8	+0.0015	C-F	Nil	"
2	1	+0.002	C-F	-0.0005	B-E
	2	+0.003	A-D	-0.0015	"
	3	+0.002	C-F	-0.001	"
3	1	+0.003	B-E	-0.001	A-D
	2	+0.001	"	-0.0005	"
4	1	+0.003	B-E	-0.002	C-F
	2	+0.0025	A-D	-0.0015	"
5	1	+0.001	A-D	-0.001	B-E
	2	+0.003	"	-0.002	C-F
6	1	+0.003	C-F	-0.002	A-D
7	1	+0.004	B-E	-0.0015	A-D
8	1	+0.004	A-D	-0.002	C-F
9	1	+0.002	F-C	-0.002	B-E
10	1	+0.002	B-E	-0.001	A-D
11	1	+0.003	A-D	-0.0025	B-E
12	1	+0.002	B-E	-0.002	C-F

APPENDIX LJ (Contd)

Mechanical Properties of 1" dia. x 24 S.W.G. x T26 Steel Tubing

Specimen No.	Direction of Grain	$E \times 10^{-6}$	L.P.	0.1% P.S.	0.2% P.S.	0.5% P.S.	Max. Stress	Elongation %
1	L	27.5	10.0	22.0	22.5	22.9	33.5	27.0
	T	26.5	8.3	22.8	24.6	26.6	35.4	20.0

Since all specimens were cut from one length of tube, the above results were applied in all cases.

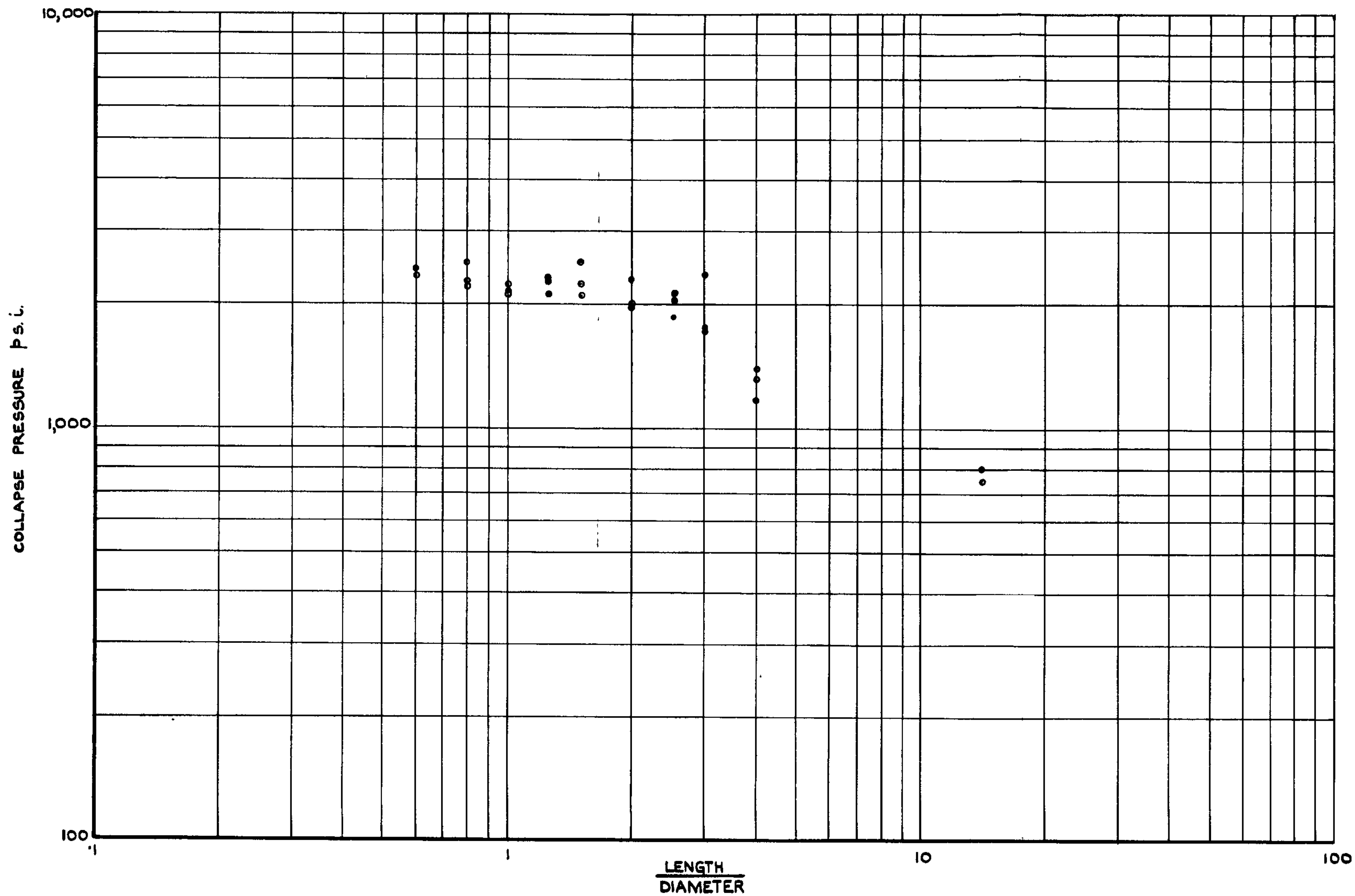
APPENDIX LJ (Contd)

Results of Tests on 1" dia. x 24 S.W.G. x T26 Tubes under Uniform External Pressure applied to the sides only

Tube No.	Collapse Pressure	$\frac{L}{D}$	Number of lobes formed	Number of lobes in complete periphery
1.1	800	14	2	2
2.1	750		2	2
3.1	860		2	2
1.2	1180	4	2	2
2.2	1410		2	2
3.2	1330		2	2
1.3	2370*	3	3	3
2.3	1750		3	3
3.3	1730		3	3
1.4	2050	2.5	3	3
2.4	2120		3	3
3.4	1860		3	3
1.5	2000	2.0	4	4
2.5	2300		3	3
3.5	1970		3	3
1.6	2550	1.5	4	4
2.6	2250		4	4
3.6	2100		4	4
1.7	2320	1.25	4	4
2.7	2270		4	4
3.7	2120		4	4
1.8	2250	1.0	4	4
2.8	2170		4	4
3.8	2130		4	5
1.9	2550	0.8	4	5
2.9	2220		3	5
3.9	2270		5	5
1.10	2350	0.6	5	5
2.10	2350		1	5
3.10	2460		4	5

* Unreliable result.

Attached: Drg. SME.75474/R



RESULTS OF TESTS ON 1" DIA. × 24 S.W.G. × T 26 TUBE
UNDER UNIFORM EXTERNAL PRESSURE APPLIED TO THE SIDES ONLY.

APPENDIX IK

Variation of tube thickness of 1" dia. × 24 swg × DTD 102A Steel tube showing relation between wall thickness and collapse pattern. SET I

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.0235	0.0235	0.0245	0.0250	0.0245	0.0230	0.0240
	2	0.0230	0.0235	0.0245	0.0250	0.0245	0.0230	0.0239
	3	0.0230	0.0235	0.0245	0.0240	0.0240	0.0230	0.0237
	4	0.0230	0.0230	0.0240	0.0240	0.0240	0.0230	0.0235
	5	0.0230	0.0230	0.0240	0.0245	0.0240	0.0230	0.0236
	6	0.0230	0.0230	0.0240	0.0240	0.0235	0.0230	0.0234
	7	0.0225	0.0225	0.0235	0.0240	0.0240	0.0225	0.0232
	8	0.0225	0.0225	0.0235	0.0240	0.0245	0.0230	0.0233
2	1	0.0235	0.0235	0.0235	0.0225	0.0225	0.0230	0.0231
	2	0.0235	0.0235	0.0235	0.0230	0.0230	0.0220	0.0231
	3	0.0235	0.0235	0.0235	0.0235	0.0230	0.0230	0.0233
3	1	0.0225	0.0230	0.0225	0.0240	0.0235	0.0235	0.0232
	2	0.0220	0.0230	0.0225	0.0240	0.0235	0.0235	0.0231
4	1	0.0240	0.0245	0.0240	0.0230	0.0230	0.0230	0.0236
	2	0.0235	0.0240	0.0240	0.0220	0.0225	0.0230	0.0232
5	1	0.0230	0.0230	0.0240	0.0240	0.0240	0.0230	0.0235
	2	0.0230	0.0235	0.0240	0.0245	0.0240	0.0230	0.0237
6	1	0.0230	0.0225	0.0230	0.0240	0.0250	0.0230	0.0234
7	1	0.0230	0.0220	0.0235	0.0235	0.0250	0.0235	0.0234
8	1	0.0245	0.0250	0.0235	0.0230	0.0230	0.0240	0.0238
9	1	0.0225	0.0230	0.0235	0.0250	0.0245	0.0235	0.0237
10	1	0.0225	0.0230	0.0250	0.0245	0.0235	0.0230	0.0236
11	1	0.0250	0.0240	0.0230	0.0225	0.0235	0.0245	0.0238
12	1	0.0250	0.0240	0.0230	0.0225	0.0235	0.0245	0.0238

APPENDIX IK (Contd)

Variation of tube thickness of 1" dia. × 24 swg × DTD 102A Steel tube showing relation between wall thickness and collapse pattern. SET II

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.0245	0.0250	0.0240	0.0225	0.0220	0.0220	0.0233
	2	0.0250	0.0255	0.0240	0.0210	0.0220	0.0225	0.0233
	3	0.0245	0.0250	0.0240	0.0210	0.0220	0.0230	0.0233
	4	0.0240	0.0245	0.0240	0.0220	0.0215	0.0225	0.0231
	5	0.0240	0.0250	0.0240	0.0220	0.0215	0.0225	0.0232
	6	0.0235	0.0250	0.0240	0.0225	0.0215	0.0225	0.0232
	7	0.0245	0.0250	0.0240	0.0220	0.0215	0.0220	0.0231
	8	0.0245	0.0250	0.0240	0.0230	0.0220	0.0220	0.0234
2	1	0.0230	0.0220	0.0225	0.0235	0.0240	0.0240	0.0232
	2	0.0225	0.0220	0.0225	0.0235	0.0245	0.0240	0.0232
	3	0.0220	0.0215	0.0225	0.0240	0.0245	0.0245	0.0232
3	1	0.0220	0.0220	0.0235	0.0245	0.0240	0.0230	0.0232
	2	0.0220	0.0225	0.0240	0.0250	0.0245	0.0230	0.0235
4	1	0.0225	0.0240	0.0250	0.0245	0.0230	0.0225	0.0236
	2	0.0230	0.0245	0.0250	0.0245	0.0230	0.0225	0.0238
5	1	0.0230	0.0245	0.0250	0.0240	0.0220	0.0230	0.0236
	2	0.0230	0.0245	0.0250	0.0240	0.0230	0.0230	0.0238
6	1	0.0250	0.0240	0.0230	0.0230	0.0235	0.0250	0.0235
7	1	0.0230	0.0230	0.0235	0.0250	0.0245	0.0240	0.0238
8	1	0.0230	0.0250	0.0245	0.0240	0.0230	0.0225	0.0237
9	1	0.0245	0.0250	0.0230	0.0225	0.0230	0.0240	0.0237
10	1	0.0240	0.0235	0.0230	0.0235	0.0235	0.0250	0.0238
11	1	0.0230	0.0230	0.0250	0.0240	0.0235	0.0230	0.0236
12	1	0.0245	0.0250	0.0235	0.0230	0.0235	0.0235	0.0238

APPENDIX IK (Contd)

Variation of wall thickness of 1" dia. × 24 swg × DTD 102A Steel tube showing relation between wall thickness and collapse pattern. SET III

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.0240	0.0240	0.0250	0.0250	0.0250	0.0240	0.0245
	2	0.0235	0.0240	0.0245	0.0250	0.0240	0.0235	0.0241
	3	0.0235	0.0240	0.0245	0.0250	0.0240	0.0235	0.0241
	4	0.0235	0.0240	0.0235	0.0245	0.0240	0.0240	0.0239
	5	0.0230	0.0235	0.0245	0.0245	0.0240	0.0235	0.0238
	6	0.0230	0.0235	0.0245	0.0240	0.0240	0.0235	0.0238
	7	0.0235	0.0240	0.0230	0.0240	0.0240	0.0235	0.0238
	8	0.0240	0.0240	0.0230	0.0245	0.0240	0.0235	0.0238
2	1	0.0240	0.0245	0.0245	0.0250	0.0240	0.0235	0.0242
	2	0.0245	0.0250	0.0250	0.0240	0.0235	0.0230	0.0242
	3	0.0245	0.0250	0.0250	0.0240	0.0240	0.0235	0.0243
3	1	0.0240	0.0235	0.0245	0.0250	0.0250	0.0240	0.0243
	2	0.0240	0.0240	0.0250	0.0250	0.0240	0.0240	0.0243
4	1	0.0250	0.0250	0.0250	0.0240	0.0240	0.0240	0.0245
	2	0.0250	0.0250	0.0250	0.0235	0.0240	0.0240	0.0244
5	1	0.0240	0.0240	0.0235	0.0245	0.0250	0.0250	0.0243
	2	0.0240	0.0235	0.0235	0.0245	0.0250	0.0250	0.0243
6	1	0.0250	0.0240	0.0235	0.0240	0.0240	0.0245	0.0242
7	1	0.0245	0.0250	0.0250	0.0240	0.0240	0.0240	0.0244
8	1	0.0230	0.0235	0.0245	0.0250	0.0250	0.0240	0.0242
9	1	0.0250	0.0240	0.0235	0.0235	0.0245	0.0250	0.0243
10	1	0.0235	0.0235	0.0245	0.0255	0.0250	0.0240	0.0243
11	1	0.0240	0.0240	0.0250	0.0255	0.0250	0.0245	0.0247
12	1	0.0240	0.0250	0.0255	0.0240	0.0235	0.0235	0.0243

Ovality of 1" Dia. × 24 swg × DTD 102A Steel tubes at deviation from Nominal Diameter - SET I

Tube No.	Position	Maximum	Position	Minimum	Position
1	1	+0.003	B-E	-0.001	A-D
	2	+0.003	"	-0.002	C-F
	3	+0.006	C-F	-0.003	A-D
	4	+0.007	"	-0.005	A-D
	5	+0.0035	A-D	Nil	C-F
	6	+0.003	"	Nil	C-F
	7	+0.002	B-E	+0.0005	C-F
	8	+0.0015	C-F	-0.001	A-D
2	1	+0.0035	C-F	-0.0015	B-E
	2	+0.0035	"	-0.0005	A-D
	3	+0.0025	"	-0.002	B-E
3	1	+0.004	A-D	-0.002	B-E
	2	+0.004	"	-0.003	"
4	1	+0.003	B-E	Nil	C-F
	2	+0.004	C-F	-0.004	A-D
5	1	+0.002	B-E	Nil	A-D
	2	+0.003	C-F	+0.001	"
6	1	+0.007	A-D	-0.0045	B-E
7	1	+0.0065	A-D	-0.005	B-E
8	1	+0.005	B-E	-0.003	A-D
9	1	+0.004	A-D	-0.002	C-F
10	1	+0.003	A-D	-0.001	B-E
11	1	+0.003	C-F	-0.0015	A-D
12	1	+0.004	C-F	-0.002	B-E

Ovality of 1" Dia. x 24 swg x DTD 102A Steel Tubes at Deviation from Nominal Diameter - SET II

Tube No.	Station	Maximum	Position	Minimum	Position
1	1	+0.003	A-D	-0.002	B-E
	2	+0.001	C-F	-0.001	A-D
	3	+0.003	"	-0.003	"
	4	+0.003	"	-0.003	"
	5	+0.0025	"	-0.002	B-E
	6	+0.0035	"	-0.002	"
	7	+0.003	"	-0.002	"
	8	+0.003	A-D	-0.003	"
2	1	+0.002	C-F	-0.002	B-E
	2	+0.004	B-E	-0.002	C-F
	3	+0.005	A-D	-0.005	B-E
3	1	+0.006	C-F	-0.005	B-E
	2	+0.002	"	-0.0015	A-D
4	1	+0.002	C-F	-0.001	A-D
	2	+0.002	A-D	-0.002	F-C
5	1	+0.002	A-D	-0.001	B-E
	2	+0.002	B-E	-0.001	F-C
6	1	+0.004	B-E	-0.001	A-D
7	1	+0.006	B-E	-0.003	A-D
8	1	+0.006	C-F	-0.005	B-E
9	1	+0.003	A-D	-0.004	C-F
10	1	+0.003	B-E	-0.0015	A-D
11	1	+0.006	A-D	-0.0045	B-E
12	1	+0.003	B-E	-0.002	C-F

APPENDIX IK (Contd)

Ovality of 1" Dia. × 24 swg × DTD 102A Steel tubes at deviation from Nominal Diameter - SET III

Tube No.	Station	Maximum	Position	Minimum	Position
1	1	+0.003	C-F	Nil	B-E
	2	+0.009	B-E	-0.005	F-C
	3	+0.005	"	-0.002	F-C
	4	+0.0025	"	Nil	A-D
	5	+0.005	"	-0.001	"
	6	+0.006	"	-0.0025	"
	7	+0.0055	"	-0.002	"
	8	+0.004	"	-0.0005	F-C
2	1	+0.004	C-F	-0.002	A-D
	2	+0.003	B-E	-0.001	A-D
	3	+0.002	A-D	Nil	B-E
3	1	+0.002	C-F	Nil	B-E
	2	+0.002	C-F	Nil	B-E
4	1	+0.0025	A-D	Nil	B-E
	2	+0.002	C-F	-0.001	"
5	1	+0.002	F-C	Nil	B-E
	2	+0.002	"	Nil	"
6	1	+0.005	B-E	-0.001	C-F
7	1	+0.005	A-D	-0.002	B-E
8	1	+0.005	F-C	-0.001	A-D
9	1	+0.005	B-E	-0.002	F-C
10	1	+0.007	F-C	-0.005	A-D
11	1	+0.006	B-E	-0.0015	A-D
12	1	+0.004	A-D	Nil	B-E

APPENDIX IK (Contd)

Mechanical Properties of 1" Dia. × 24 S.W.G. × D.T.D.102A Steel Tubes

Tube No.	Direction of Grain	E × 10^{-6}	L.P.	0.1% P.S.	0.2% P.S.	0.5% P.S.	Max. Stress	Elong. % on 1"
1	L	30.6	17.0	29.8	31.4	33.4	43.5	19.0
	T	30.3	8.2	27.0	30.7	34.3	42.7	14.0

Relation between Mechanical and Pressure Test Specimens

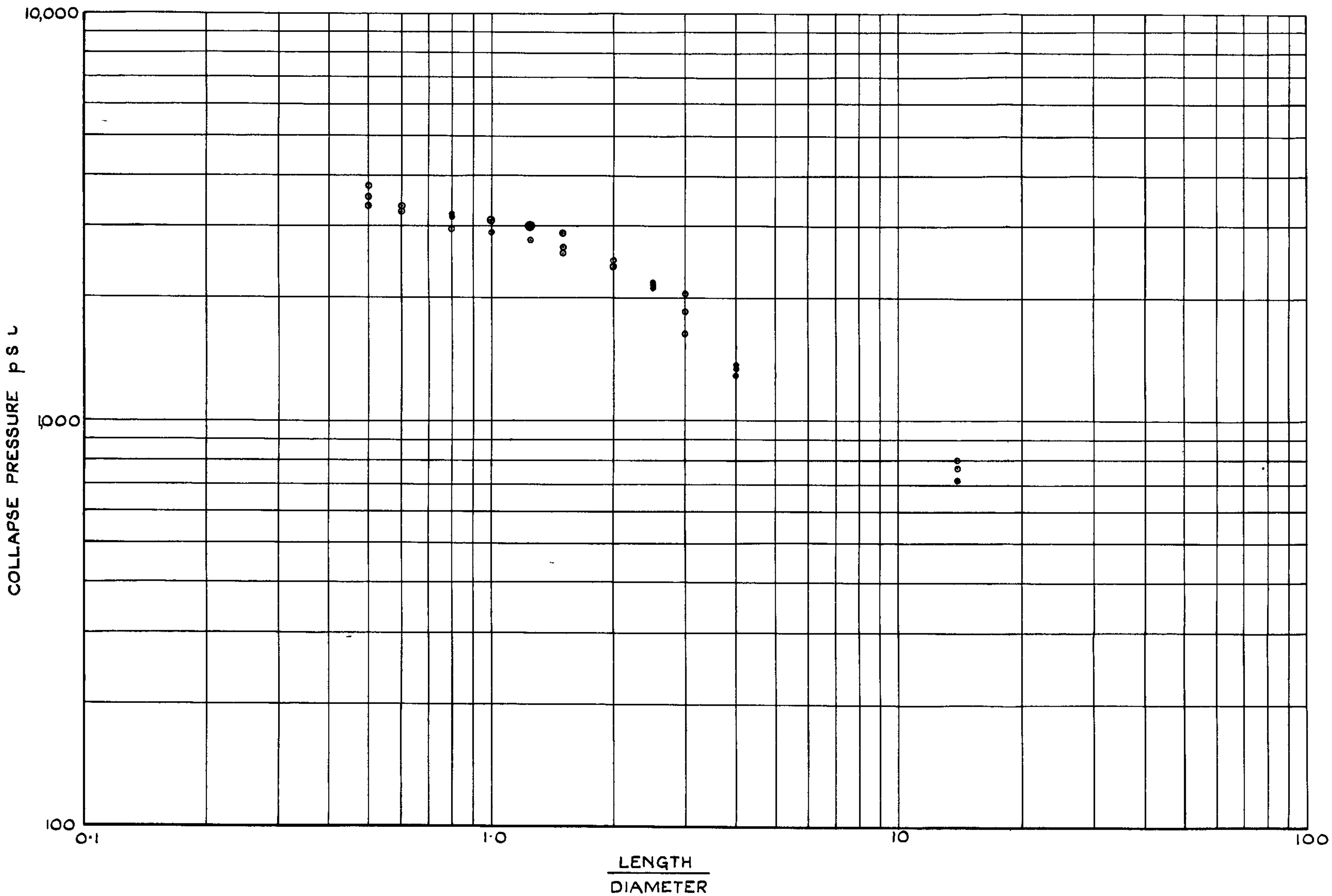
All pressure test specimens were cut from one length of tube. The results quoted above were therefore applied to all specimens.

APPENDIX IK (Contd)

Results of tests on 1" Dia. × 24 swg × DTD 102A Steel Tubes under Uniform External Pressure Applied to the Sides Only

Tube No.	Pressure	$\frac{L}{D}$	No. Lobes formed	No. Lobes in Complete Periphery
1.1	770	14	2	2
2.1	720		2	2
3.1	800		2	2
1.2	1340	4	2	3
2.2	1300		2	2
3.2	1375		2	2
1.3	1860	3	3	3
2.3	1660		3	3
3.3	2070		3	3
1.4	2170	2.5	3	3
2.4	2120		3	3
3.4	2140		3	3
1.5	2440	2.0	3	3
2.5	2400		3	3
3.5	2390		3	3
1.6	2675	1.5	4	4
2.6	2600		4	4
3.6	2890		4	4
1.7	2950	1.25	4	4
2.7	2760		4	4
3.7	2940		4	4
1.8	3075	1.0	4	4
2.8	2900		3	4
3.8	3100		3	4
1.9	3140	0.8	3	5
2.9	2950		3	4
3.9	3175		3	5
1.10	3250	0.6	2	5
2.10	3350		2	6
3.10	3300		2	6
1.11	3550	0.5	2	6
2.11	3800		2	7
3.11	3400		1	7

Attached: Drg. SME.75484/R



RESULTS OF TESTS ON 1" DIA. X 24 S.W.G. X D.T.D. 102 A STEEL TUBE UNDER UNIFORM EXTERNAL PRESSURE APPLIED TO THE SIDES ONLY.

APPENDIX II

Variation of wall thickness of 1" Dia.× 24 S.W.G. × T58 steel tubing showing relation between wall thickness and collapse pattern - Set I.

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.0255	0.0255	0.0250	0.0250	0.0250	0.0250	0.0252
	2	0.0255	0.0260	0.0250	0.0245	0.0250	0.0255	0.0253
	3	0.0260	0.0260	0.0250	0.0245	0.0250	0.0250	0.0253
	4	0.0260	0.0260	0.02525	0.0240	0.0250	0.0250	0.0252
	5	0.0255	0.0265	0.0255	0.0245	0.0250	0.0245	0.0253
	6	0.0260	0.0260	0.0250	0.0245	0.0250	0.0250	0.0253
	7	0.0260	0.0265	0.0255	0.0240	0.0250	0.0250	0.0253
	8	0.0260	0.0260	0.0250	0.0240	0.0250	0.0255	0.0253
2	1	0.0250	0.0255	0.0260	0.0250	0.0240	0.0245	0.0250
	2	0.0250	0.0255	0.0260	0.0250	0.0240	0.0245	0.0250
	3	0.0250	0.0255	0.0255	0.0250	0.0245	0.0250	0.0251
3	1	0.0245	0.0250	0.0255	0.0260	0.0250	0.0240	0.0250
	2	0.0250	0.0245	0.0250	0.0260	0.0255	0.0250	0.0252
4	1	0.0245	0.0250	0.0260	0.0255	0.0250	0.0245	0.0251
	2	0.02425	0.0250	0.0260	0.0255	0.0250	0.0250	0.0251
5	1	0.0245	0.0245	0.0245	0.0255	0.0260	0.0255	0.0251
	2	0.0245	0.0250	0.0250	0.0255	0.0260	0.0250	0.0252
6	1	0.0255	0.0260	0.0250	0.0245	0.0240	0.0245	0.0249
7	1	0.0235	0.0250	0.0265	0.0260	0.0245	0.0240	0.0249
8	1	0.0245	0.0260	0.0260	0.0255	0.0245	0.0240	0.0251
9	1	0.0260	0.0265	0.0255	0.0245	0.0235	0.0245	0.0251
10	1	0.0240	0.0235	0.0245	0.0260	0.0260	0.0250	0.0248
11	1	0.0265	0.0260	0.0250	0.0235	0.0245	0.0255	0.0252
12	1	0.0245	0.0255	0.0265	0.0255	0.0245	0.0240	0.0251
13	1	0.0255	0.0265	0.0260	0.0250	0.0240	0.0245	0.0252

APPENDIX IL (Contd)

Variation of wall thickness of 1" Dia. × 24 S.W.G. × T58 steel tubing showing relation between wall thickness and collapse pattern - Set II.

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.0255	0.0255	0.0255	0.0250	0.0250	0.0250	0.0253
	2	0.0260	0.0255	0.0255	0.0250	0.0250	0.0255	0.0254
	3	0.0255	0.0250	0.0250	0.0250	0.0250	0.0255	0.0252
	4	0.0255	0.0255	0.0250	0.0245	0.0245	0.0250	0.0250
	5	0.0260	0.0265	0.0260	0.0245	0.0240	0.0250	0.0253
	6	0.0260	0.0260	0.0255	0.0245	0.0245	0.0250	0.0253
	7	0.0260	0.0260	0.0255	0.0240	0.0245	0.0255	0.0253
	8	0.0265	0.0260	0.0255	0.0240	0.0245	0.0255	0.0253
2	1	0.0250	0.0250	0.0245	0.0250	0.0255	0.0255	0.0251
	2	0.0250	0.0250	0.0245	0.0245	0.0255	0.0255	0.0250
	3	0.0255	0.0260	0.0245	0.0245	0.0250	0.0250	0.0251
3	1	0.0260	0.0260	0.0250	0.0250	0.0250	0.0255	0.0254
	2	0.0260	0.0255	0.0250	0.0250	0.0250	0.0250	0.0253
4	1	0.0255	0.0260	0.0260	0.0250	0.0250	0.0250	0.0254
	2	0.0255	0.0260	0.0255	0.0245	0.0250	0.0250	0.0253
5	1	0.0260	0.0255	0.0250	0.0250	0.0250	0.0255	0.0253
	2	0.0260	0.0255	0.0245	0.0250	0.0250	0.0260	0.0253
6	1	0.0265	0.0255	0.0245	0.0250	0.0255	0.0260	0.0255
7	1	0.0250	0.0245	0.0245	0.0260	0.0270	0.0260	0.0255
8	1	0.0260	0.0270	0.0260	0.0245	0.0245	0.0250	0.0255
9	1	0.0245	0.0240	0.0245	0.0255	0.0270	0.0265	0.0253
10	1	0.0255	0.0265	0.0265	0.0255	0.0250	0.0240	0.0255
11	1	0.0250	0.0265	0.0260	0.0250	0.0245	0.0250	0.0253
12	1	0.0245	0.0245	0.0245	0.0260	0.0270	0.0255	0.0253
13	1	0.0250	0.0265	0.0260	0.0250	0.0245	0.0240	0.0252

APPENDIX IL (Contd)

Variation of wall thickness of 1" Dia. × 24 S.W.G. × T58 steel tubing showing relation between wall thickness and collapse pattern - Set III

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.0250	0.0270	0.0280	0.0270	0.0250	0.0245	0.0261
	2	0.0250	0.0270	0.0285	0.0270	0.0240	0.0235	0.0258
	3	0.0250	0.0265	0.0280	0.0270	0.0250	0.0245	0.0260
	4	0.0250	0.0260	0.0280	0.0270	0.0250	0.0245	0.0259
	5	0.0250	0.0270	0.0275	0.0265	0.0250	0.0240	0.0258
	6	0.0250	0.0260	0.0270	0.0270	0.0260	0.0245	0.0258
	7	0.0250	0.0260	0.0270	0.0270	0.0260	0.0250	0.0260
	8	0.0260	0.0270	0.0275	0.0265	0.0250	0.0245	0.0261
2	1	0.0250	0.0260	0.0270	0.0275	0.0260	0.0240	0.0259
	2	0.0245	0.0260	0.0275	0.0270	0.0255	0.0240	0.0258
	3	0.0250	0.0255	0.0270	0.0270	0.0260	0.0250	0.0259
3	1	0.0245	0.0250	0.0260	0.0270	0.0270	0.0260	0.0259
	2	0.0250	0.0250	0.0260	0.0270	0.0270	0.0260	0.0260
4	1	0.0250	0.0260	0.0270	0.0270	0.0255	0.0250	0.0259
	2	0.0250	0.0260	0.0270	0.0270	0.0260	0.0245	0.0259
5	1	0.0265	0.0270	0.0265	0.0255	0.0245	0.0250	0.0258
	2	0.0260	0.0265	0.0250	0.0255	0.0250	0.0250	0.0255
6	1	0.0240	0.0250	0.0245	0.0270	0.0260	0.0250	0.0253
7	1	0.0250	0.0250	0.0240	0.0255	0.0265	0.0265	0.0254
8	1	0.025	0.0245	0.0255	0.0265	0.0270	0.0260	0.0258
9	1	0.0245	0.0250	0.0265	0.0270	0.0260	0.0250	0.0257
10	1	0.0250	0.0250	0.0255	0.0260	0.0255	0.0250	0.0253
11	1	0.0250	0.0250	0.0255	0.0260	0.0255	0.0250	0.0253
12	1	0.0250	0.0260	0.0260	0.0260	0.0255	0.0250	0.0256
13	1	0.0260	0.0260	0.0255	0.0255	0.0250	0.0255	0.0256

APPENDIX IL (Contd)

Ovality of 1" Dia. × 24 S.W.G. × T58 Steel Tubing as Deviation from Nominal Diameter - Set I

Tube No	Station	Maximum	Position	Minimum	Position
1	1	+0.0035	A-D	+0.0025	B-E
	2	+0.004	"	+0.002	"
	3	+0.004	"	+0.0025	"
	4	+0.0045	"	+0.002	C-F
	5	+0.005	"	+0.0025	"
	6	+0.005	"	+0.002	B-E
	7	+0.004	"	+0.002	"
	8	+0.0035	"	+0.0025	C-F
2	1	+0.0035	C-F	+0.003	A-D
	2	+0.004	B-E	+0.0015	"
	3	+0.003	C-F	+0.0025	"
3	1	+0.004	A-D	+0.0025	B-E
	2	+0.003	B-E	+0.0015	C-F
4	1	+0.003	B-E	+0.0015	A-D
	2	+0.004	"	+0.0005	"
5	1	+0.003	C-F	+0.001	A-D
	2	+0.003	"	+0.0015	"
6	1	+0.0055	B-E	+0.002	A-D
7	1	+0.006	A-D	+0.0015	C-F
8	1	+0.006	C-F	+0.001	B-E
9	1	+0.0065	B-E	+0.001	A-D
10	1	+0.005	A-D	+0.003	C-F
11	1	+0.005	C-F	+0.003	B-E
12	1	+0.0045	A-D	+0.003	B-E

Ovality of 1" Dia. × 24 S.W.G. × T58 Steel Tubes as Deviation from Nominal Diameter - Set II

Tube No	Station	Maximum	Position	Minimum	Position
1	1	+0.004	B-E	+0.0035	A-D
	2	+0.0045	"	+0.003	C-F
	3	+0.004	"	+0.003	"
	4	+0.004	"	+0.0025	"
	5	+0.0035	C-F	+0.002	B-E
	6	+0.0035	"	+0.0025	"
	7	+0.004	"	+0.0025	"
	8	+0.003	"	+0.0025	"
2	1	+0.004	A-D	+0.0035	B-E
	2	+0.004	"	+0.0035	"
	3	+0.0045	"	+0.0035	"
3	1	+0.0045	C-F	+0.0035	A-D
	2	+0.0045	"	+0.003	"
4	1	+0.005	A-D	+0.003	E-B
	2	+0.004	"	+0.003	"
5	1	+0.004	C-F	+0.003	E-B
	2	+0.004	E-B	+0.0035	C-F
6	1	+0.0045	F-C	+0.0035	E-B
7	1	+0.005	F-C	+0.002	A-D
8	1	+0.0055	A-D	+0.0025	C-F
9	1	+0.005	E-B	+0.0025	C-F
10	1	+0.0055	C-F	+0.0025	B-E
11	1	+0.005	A-D	+0.003	B-E
12	1	+0.005	C-F	+0.003	B-E

APPENDIX IL (Contd)

Ovality of 1" Dia. × 24 S.W.G. × T58 Steel Tubes as Deviation from Nominal Diameter - Set III

Tube No	Station	Maximum	Position	Minimum	Position
1	1	+0.0065	B-E	+0.001	A-D
	2	+0.005	C-F	+0.003	"
	3	+0.0065	"	+0.001	"
	4	+0.0065	"	+0.001	"
	5	+0.006	B-E	+0.0015	"
	6	+0.006	"	+0.002	"
	7	+0.006	"	+0.0025	"
	8	+0.006	C-F	+0.002	"
2	1	+0.0055	A-D	+0.003	B-E
	2	+0.006	C-F	+0.002	"
	3	+0.006	"	+0.0015	"
3	1	+0.005	A-D	+0.0025	C-F
	2	+0.0055	B-E	+0.002	C-F
4	1	+0.004	C-F	+0.0025	B-E
	2	+0.005	"	+0.0025	"
5	1	+0.004	A-D	+0.003	B-E
	2	+0.004	C-F	+0.003	A-D
6	1	+0.004	B-E	+0.003	C-F
7	1	+0.005	C-F	+0.002	A-D
8	1	+0.006	B-E	+0.001	C-F
9	1	+0.006	A-D	+0.001	B-E
10	1	+0.005	A-D	+0.001	B-E
11	1	+0.006	A-D	+0.001	B-E
12	1	+0.005	C-F	+0.001	B-E

APPENDIX II (Contd)

Mechanical Properties of 1" Dia. × 24 S.W.G. × T58 Steel Tubing

Specimen No.	Direction of Grain	E × 10^{-6}	L.P.	0.1% P.S.	0.2% P.S.	0.5% P.S.	Max. Stress	Elong. % on 1"
1	L	28.6	12.6	45.0	49.4	53.6	58.4	15.0
	T	25.6	6.0	43.4	50.6	57.4	61.7	3.0

Relation between Mechanical and Pressure Test Specimens

Since all the pressure test specimens were cut from the same length of tube, the results given above were applied in all cases.

APPENDIX IL (Contd)

Results of Tests on 1" Dia. x 24 S.W.G. x T58 Steel Tubes under Uniform External Pressure Applied to the Sides Only

Tube No	Collapse pressure	L/D	No. Lobes Formed	No. Lobes in complete periphery
1.1	1040	14	2	2
2.1	1075	"	2	2
3.1	1000	"	2	2
1.2	1720	4	2	2
2.2	1875		2	2
3.2	1625		2	2
1.3	2780	3.0	3	3
2.3	2775		3	3
3.3	2750		2	3
1.4	3180	2.5	3	3
2.4	3050		3	3
3.4	2950		3	3
1.5	3520	2.0	3	3
2.5	3730		3	3
3.5	3450		3	3
1.6	4530	1.5	4	4
2.6	4600		4	4
3.6	4475		3	3
1.7	5050	1.25	4	4
2.7	4950		4	4
3.7	4875		4	4
1.8	5400	1.0	4	4
2.8	5650		4	4
3.8	5575		4	4
1.9	6050	0.85	4	4
2.9	5720		4	4
3.9	6050		4	4
1.10	6500	0.6	3	6
2.10	6320		2	6
3.10	6650		3	4
1.11	6850	0.5	1	6
2.11	7330		3	5
3.11	7200		2	6
1.12	-			
2.12	8300	0.4	2	8
3.12	-			

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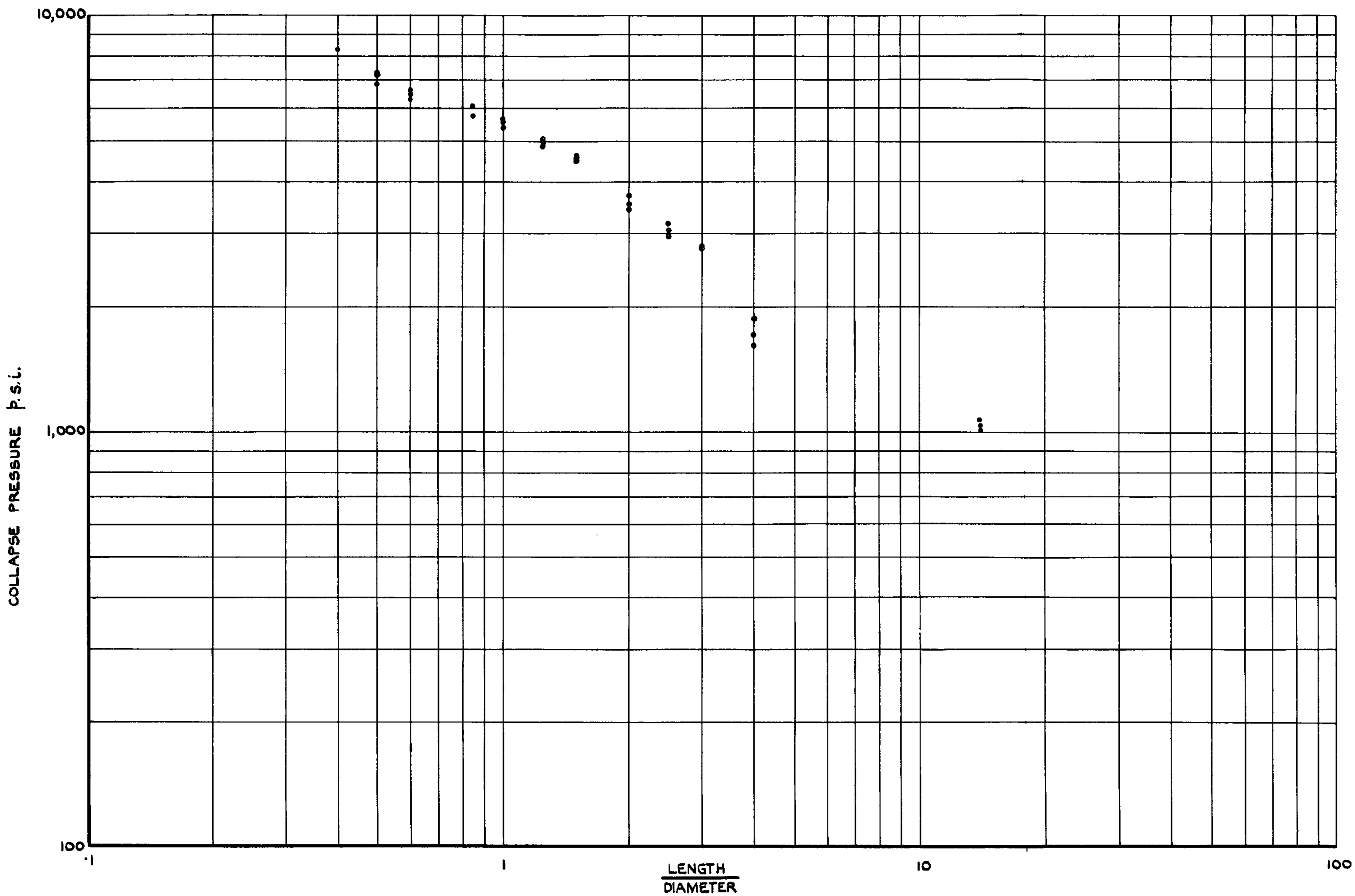


RESULTS OF TESTS ON 1" DIA. × 24 S.W.G. × T 58 STEEL TUBES UNDER UNIFORM EXTERNAL PRESSURE APPLIED TO THE SIDES ONLY.

APPENDIX IM

Variation in tube thickness for 1" Dia. × 24 S.W.G. × D.T.D.460 Light Alloy Tubes showing relation between wall thickness and collapse pattern

SET 1

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.0230	0.0230	0.02275	0.0225	0.0225	0.0225	0.0225
	2	0.0225	0.02275	0.0225	0.023	0.023	0.02275	0.02275
	3	0.0225	0.023	0.023	0.023	0.0225	0.02225	0.02272
	4	0.023	0.023	0.02275	0.0225	0.02225	0.02225	0.02262
	5	0.02225	0.0225	0.023	0.02375	0.023	0.0225	0.02283
	6	0.02275	0.023	0.023	0.023	0.02275	0.0225	0.02280
	7	0.0225	0.02275	0.023	0.02325	0.023	0.0225	0.02283
	8	0.02275	0.023	0.023	0.023	0.02275	0.0225	0.02283
2	1	0.02275	0.02325	0.023	0.023	0.0225	0.02225	0.02280
	2	0.02275	0.023	0.02275	0.02275	0.0225	0.0225	0.02271
	3	0.0225	0.023	0.023	0.023	0.02275	0.02225	0.02275
	4	0.02275	0.023	0.023	0.02275	0.0225	0.0225	0.02275
3	1	0.0225	0.023	0.023	0.023	0.02275	0.0225	0.0228
	2	0.0225	0.023	0.023	0.02275	0.02275	0.0225	0.02275
	3	0.0225	0.023	0.023	0.023	0.0225	0.02225	0.02282
4	1	0.023	0.02275	0.02275	0.0225	0.0225	0.023	0.02275
	2	0.023	0.02275	0.02275	0.0225	0.0225	0.023	0.02275
	3	0.02275	0.02275	0.02275	0.02225	0.02225	0.0225	0.02254
5	1	0.02225	0.02225	0.0225	0.02225	0.02225	0.0225	0.0223
	2	0.023	0.023	0.02275	0.02275	0.0225	0.02275	0.02228
6	1	0.023	0.023	0.02325	0.023	0.02275	0.023	0.0230
7	1	0.0225	0.0225	0.0225	0.023	0.02325	0.023	0.02280
8	1	0.0225	0.023	0.023	0.023	0.02275	0.0225	0.0228
9	1	0.02275	0.0225	0.02225	0.023	0.02325	0.02325	0.02283
10	1	0.023	0.02325	0.023	0.0225	0.0225	0.023	0.02287
11	1	0.023	0.02325	0.023	0.0225	0.0225	0.023	0.02287
12	1	0.023	0.02325	0.02325	0.023	0.0225	0.0225	0.0229

Variation in tube thickness for 1" Dia. × 24 S.W.G. × D.T.D.460 Light Alloy Tubes showing relation between wall thickness and collapse pattern

SET 2

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.023	0.023	0.0225	0.02275	0.023	0.023	0.02290
	2	0.02325	0.02275	0.0225	0.0225	0.023	0.023	0.02280
	3	0.023	0.02325	0.0225	0.02275	0.023	0.023	0.02290
	4	0.02325	0.023	0.0225	0.0225	0.023	0.023	0.02290
	5	0.02325	0.02325	0.02275	0.02275	0.023	0.023	0.02300
	6	0.02325	0.023	0.02275	0.02275	0.023	0.023	0.02290
	7	0.023	0.0225	0.0225	0.0225	0.023	0.023	0.02275
	8	0.02325	0.023	0.02275	0.0225	0.023	0.023	0.02290
2	1	0.02275	0.023	0.023	0.023	0.02275	0.0225	0.02280
	2	0.02275	0.023	0.023	0.023	0.02275	0.02250	0.02275
	3	0.023	0.023	0.023	0.023	0.02275	0.02275	0.0229
	4	0.023	0.023	0.023	0.023	0.02275	0.02275	0.0229
3	1	0.02275	0.023	0.023	0.023	0.023	0.02275	0.0229
	2	0.0225	0.02325	0.02325	0.023	0.0225	0.0225	0.0228
	3	0.02275	0.023	0.023	0.023	0.023	0.0225	0.0228
4	1	0.023	0.02275	0.02275	0.023	0.023	0.02275	0.0229
	2	0.02275	0.0225	0.023	0.02325	0.023	0.02275	0.0229
	3	0.023	0.02275	0.0225	0.02275	0.02275	0.023	0.0228
5	1	0.02275	0.023	0.023	0.02275	0.0225	0.0225	0.02275
	2	0.02275	0.023	0.023	0.0225	0.02225	0.0225	0.0227
6	1	0.0225	0.0225	0.0225	0.023	0.023	0.023	0.02275
7	1	0.02325	0.02275	0.0225	0.0225	0.02275	0.023	0.0228
8	1	0.02275	0.02275	0.023	0.023	0.02275	0.02275	0.0228
9	1	0.023	0.0225	0.0225	0.02275	0.023	0.023	0.0228
10	1	0.023	0.023	0.023	0.023	0.02275	0.023	0.0230
11	1	0.023	0.023	0.02325	0.023	0.02275	0.02275	0.0230
12	1	0.02325	0.02325	0.02325	0.023	0.0225	0.02275	0.0230

APPENDIX IM (Contd)

Variation in tube thickness for 1" Dia. × 24 S.W.G. × D.T.D.460 Light Alloy Tubes showing relation between wall thickness and collapse pattern

SET 3

Tube No.	Station	A	B	C	D	E	F	Mean
1	1	0.0225	0.0225	0.02325	0.0235	0.02325	0.023	0.0230
	2	0.02275	0.02275	0.02325	0.0235	0.0235	0.02325	0.0230
	3	0.0225	0.0225	0.02325	0.0235	0.0235	0.023	0.0230
	4	0.0225	0.0225	0.02325	0.0235	0.02325	0.023	0.0230
	5	0.0225	0.02275	0.0235	0.0235	0.02325	0.023	0.0231
	6	0.0225	0.02275	0.0235	0.02325	0.0235	0.023	0.0231
	7	0.0225	0.0225	0.0235	0.0235	0.0235	0.023	0.0231
	8	0.0225	0.0225	0.0235	0.0235	0.02325	0.023	0.023
2	1	0.0225	0.02325	0.0235	0.02325	0.023	0.02225	0.023
	2	0.0225	0.0235	0.0235	0.0235	0.023	0.0225	0.0231
	3	0.0225	0.0235	0.0235	0.02325	0.023	0.0225	0.0231
	4	0.0225	0.02325	0.0235	0.0235	0.023	0.0225	0.0230
3	1	0.0225	0.0225	0.023	0.0235	0.0235	0.02325	0.0230
	2	0.023	0.0225	0.02325	0.0235	0.0235	0.02325	0.0232
	3	0.0225	0.0225	0.023	0.02325	0.02325	0.023	0.0229
4	1	0.023	0.0235	0.0235	0.02325	0.02275	0.0225	0.0231
	2	0.023	0.0235	0.0235	0.02325	0.02275	0.0225	0.0231
	3	0.023	0.0235	0.0235	0.02325	0.0225	0.0225	0.023
5	1	0.02325	0.0235	0.023	0.02225	0.02225	0.023	0.0229
	2	0.02325	0.02325	0.023	0.02225	0.02225	0.023	0.0228
6	1	0.0235	0.02325	0.02275	0.02225	0.023	0.0235	0.023
7	1	0.023	0.02225	0.022	0.023	0.02375	0.0235	0.0229
8	1	0.023	0.0235	0.0235	0.02325	0.0225	0.02275	0.023
9	1	0.02325	0.02375	0.0235	0.023	0.02225	0.02275	0.023
10	1	0.02325	0.02325	0.02325	0.0225	0.02225	0.02275	0.0229
11	1	0.0225	0.023	0.02325	0.02325	0.02275	0.02225	0.0228
12	1	0.02275	0.02325	0.02325	0.023	0.0225	0.0225	0.0229

APPENDIX IM (Contd)

Ovality of 1" Dia. × 24 S.W.G. × D.T.D.460 Aluminium Alloy Tubes - Set I

Tube No.	Ovality
1.1	Approximately 0.002" over whole length
1.2	" 0.002 " " "
1.3	" 0.002 " " "
1.4	" 0.003 " " "
1.5	" 0.002 " " "
1.6	" 0.003 " " "
1.7	" 0.001 " " "
1.8	" 0.001 " " "
1.9	" 0.001 " " "
1.10	" 0.001 " " "
1.11	" 0.001 " " "
1.12	" 0.001 " " "

Ovality of 1" Dia. × 24 S.W.G. × D.T.D.460 Aluminium Alloy Tubes - Set II

Tube No.	Ovality
2.1	Approximately 0.002" over whole length
2.2	" 0.003 " " "
2.3	" 0.003 " " "
2.4	" 0.002 " " "
2.5	" 0.002 " " "
2.6	" 0.002 " " "
2.7	" 0.0025 " " "
2.8	" 0.0025 " " "
2.9	" 0.003 " " "
2.10	" 0.003 " " "
2.11	" 0.0025 " " "
2.12	" 0.0025 " " "

Ovality of 1" Dia. × 24 S.W.G. × D.T.D.460 Aluminium Alloy Tubes - Set III

Tube No.	Ovality
3.1	Approximately 0.002" over whole length
3.2	" 0.002 " " "
3.3	" 0.001 " " "
3.4	" 0.002 " " "
3.5	" 0.002 " " "
3.6	" 0.002 " " "
3.7	" 0.0015 " " "
3.8	" 0.002 " " "
3.9	" 0.002 " " "
3.10	" 0.002 " " "
3.11	" 0.002 " " "
3.12	" 0.002 " " "
3.13	" 0.002 " " "
3.14	" 0.003 " " "

Mechanical Properties of 1" Dia. × 24 S.W.G. × D.T.D.460 Light Alloy Tubes

Specimen No.	Direction of Grain	E ×10^{-6}	L.P.	0.1% P.S.	0.2% P.S.	0.5% P.S.	Max. Stress	Elongation % on 1"
A1	L	10.1	10.5	20.8	23.2	24.5	26.6	8.0
A4	T	10.4	15.4	26.5	27.4	27.8	28.5	2.0
B1	L	10.4	10.4	22.7	24.0	25.2	26.7	8.0
B3	T	10.0	17.0	27.1	27.9	28.2	28.9	4.0

Note:

Transverse specimens were manufactured from opened out rings, which had been rolled flat. This operation resulted in a reduction of thickness of about 5% and has probably raised the transverse strength figures to an incorrect value.

Location of Mechanical Set. Specimens relative to Pressure Test Specimens

Mechanical Test Specimen	Relative Pressure Specimen Set
A	Set 3
B	Sets 1 and 2

APPENDIX IM (Contd)

Results of Tests on 1" Dia. × 24 S.W.G. × D.T.D.460 Light Alloy Tubes under uniform external pressure applied to the side only

Tube No.	Corrected collapse pressure	L/D	Number Lobes actually formed	Number Lobes in complete periphery
1.1 2.1 3.1	280 286 280	14	2 " -	2 " -
1.2 2.2 3.2	388 388 370	5	2 " "	2 " "
1.3 2.3 3.3	518 560 490	4	2 " "	2 " "
1.4 2.4 3.4	850 778 760	3	3 " "	3 " "
1.5 2.5 3.5	1020 1050 990	2	2 3 3	3 3 3
1.6 2.6 3.6	1620 1580 1410	1.5	4 " 4	4 " 4
1.7 2.7 3.7	1780 1700 1770	1.25	4 " "	4 " "
1.8 2.8 3.8	1890 1870 1980	1.0	3 4 4	4 4 4
1.9 2.9 3.9	2080 2190 2150	0.8	4 5 4	5 5 5
1.10 2.10 3.10	2400 2420 2330	0.6	4 4 3	5 5 5
1.11 2.11 3.11	2560 2510 2480	0.5	1 1 2	6 6 6
1.12 2.12 3.12	2940 2880 2910	0.4	2 2 1	6 6 6
3.13* 3.14*	3340 4190	0.3 0.2	- -	- -

* Results unreliable

Attached: Drg. SME.75130/R

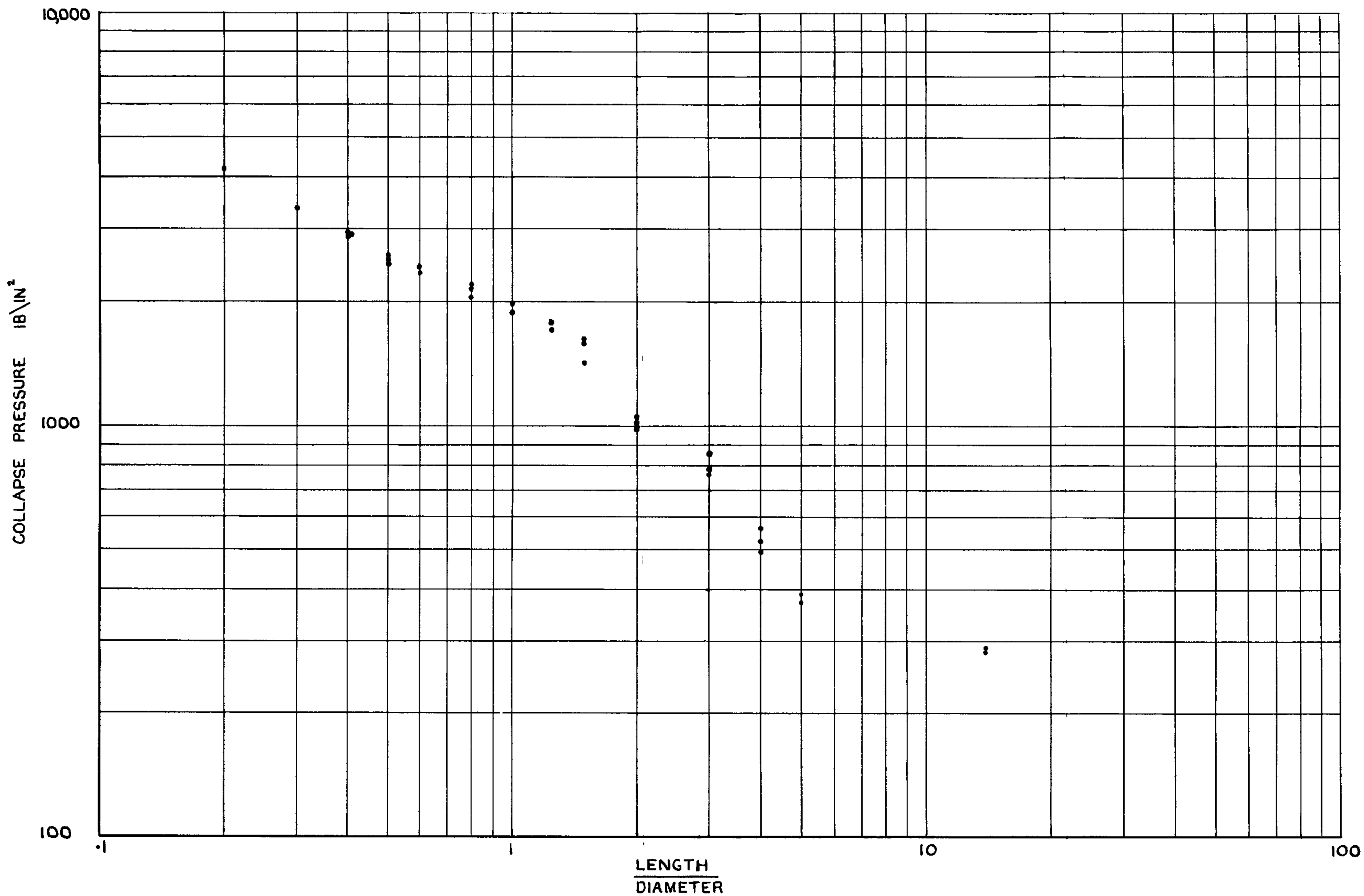


FIG. 2 – RESULTS OF TESTS ON 1" DIA. X 24 SWG. X DTD 460 LIGHT ALLOY TUBING UNDER UNIFORM EXTERNAL PRESSURE.

APPENDIX IV

Variation of Wall Thickness of 1" Dia. × 24 S.W.G. Brass Tubing showing correlation with Collapse Pattern - Set 1

Tube No.	Station	A	B	C	D	E	F	Mean
1.1	1	0.0215	0.022	0.022	0.021	0.0205	0.021	0.0213
	2	0.021	"	0.0215	"	0.021	0.021	0.02125
	3	"	"	"	"	0.021	0.0205	0.0212
	4	"	"	"	0.0205	0.0205	"	0.021
	5	"	"	"	"	0.021	"	0.0211
	6	"	"	"	"	0.0205	"	0.021
	7	"	"	"	"	0.021	"	0.0211
	8	"	"	"	"	0.0205	"	0.021
1.2	1	0.02075	0.0215	0.022	0.021	0.02025	0.0205	0.021
	2	"	"	"	0.021	"	0.02025	0.021
	3	0.021	0.022	"	0.0215	0.0205	0.0205	0.0213
1.3	1	0.021	0.0205	0.0205	0.021	0.022	0.022	0.0212
	2	"	"	"	0.021	"	"	0.0212
	3	"	"	"	0.021	"	0.0225	0.0212
1.4	1	0.0205	0.021	0.02225	0.022	0.021	0.0205	0.0212
	2	"	"	0.0225	0.0225	"	0.0205	0.0213
1.5	1	0.02175	0.021	0.0205	0.0205	0.0215	0.022	0.0212
1.6	1	0.0215	0.02025	0.02025	0.0205	0.021	0.022	0.0209
1.7	1	0.022	0.02225	0.021	0.0205	0.0205	0.021	0.0212
1.8	1	0.021	0.0205	0.0205	0.021	0.022	0.022	0.0212
1.9	1	0.021	0.02075	0.021	0.021	0.022	0.0225	0.0214
1.10	1	0.021	0.0215	0.0225	0.022	0.021	0.021	0.0215
1.11	1	0.022	0.021	0.02075	0.021	0.021	0.022	0.0213
1.12	1	0.021	0.02175	0.0225	0.0215	0.0205	0.0205	0.0213
1.13	1	0.021	0.0205	0.021	0.0225	0.022	0.021	0.0213
1.14	1	0.022	0.0225	0.0215	0.021	0.0205	0.021	0.0214

APPENDIX IV (Contd)

Variation of Wall Thickness of 1" Dia. × 24 S.W.G. Brass Tubing showing correlation with Collapse Pattern - Set 2

Tube No.	Station	A	B	C	D	E	F	Mean
2.1	1	0.024	0.2425	0.0235	0.023	0.0225	0.0225	0.0233
	2	"	0.024	0.024	0.02325	0.023	"	0.0235
	3	"	"	0.023	0.02275	0.0225	"	0.0231
	4	"	"	0.023	0.0225	"	"	0.0231
	5	"	"	0.0235	0.02275	"	"	0.0232
	6	"	"	"	"	"	0.02275	0.0232
	7	"	"	"	"	"	0.0225	0.0232
	8	"	"	"	0.023	0.02275	"	0.0233
2.2	1	0.022	0.02175	0.0215	0.0225	0.023	0.0225	0.0222
	2	0.02175	"	"	"	0.02325	0.0225	0.0222
	3	0.02125	0.022	"	0.023	0.0235	0.023	0.0225
2.3	1	0.0215	0.023	0.023	0.0225	0.02175	0.0215	0.0222
	2	0.02175	0.0235	"	0.02225	"	"	0.0223
	3	0.0215	"	"	0.0225	0.0215	"	0.0224
2.4	1	0.022	0.022	0.022	0.0225	0.023	0.023	0.0224
	2	0.021	"	"	0.023	0.0235	"	0.0224
2.5	1	0.022	0.022	0.02275	0.023	0.02225	0.0215	0.0223
2.6	1	0.02125	0.0225	0.0235	0.023	0.022	0.022	0.0224
2.7	1	0.022	0.023	0.0235	0.022	0.021	0.022	0.0223
2.8	1	0.022	0.0215	0.0215	0.0235	0.023	0.022	0.0223
2.9	1	0.022	0.022	0.0215	0.023	0.02325	0.0225	0.0224
2.10	1	0.02325	0.0235	0.0225	0.0215	0.022	0.022	0.0225
2.11	1	0.023	0.022	0.022	0.022	0.022	0.023	0.0223
2.12	1	0.022	0.0215	0.022	0.023	0.023	0.02225	0.0223
2.13	1	0.023	0.022	0.022	0.0215	0.0225	0.0235	0.0224
2.14	1	0.0235	0.02275	0.022	0.02175	0.0215	0.023	0.0224

APPENDIX IN (Contd)

Variation of Wall Thickness of 1" Dia. x 24 S.W.G. Brass Tubing showing correlation with Collapse Pattern - Set 3

Tube No.	Station	A	B	C	D	E	F	Mean
3.1	1	0.0215	0.02275	0.02275	0.0215	0.021	0.021	0.0217
	2	0.021	0.02275	0.023	"	"	"	0.0217
	3	0.0215	0.0225	0.0225	0.021	"	0.02125	0.0216
	4	"	0.022	0.0225	0.0215	"	0.021	0.0216
	5	"	0.0225	0.02275	"	"	"	0.0217
	6	"	0.023	0.023	"	"	"	0.0218
	7	"	0.02275	"	"	"	0.02125	0.0218
	8	0.022	0.023	"	"	"	0.0215	0.022
3.2	1	0.0215	0.022	0.023	0.023	0.0215	0.021	0.022
	2	0.02125	0.0215	0.0225	"	0.022	"	0.0219
	3	0.0215	0.022	0.023	"	0.0215	0.0215	0.0221
3.3	1	0.021	0.0215	0.022	0.023	0.0225	0.0215	0.0219
	2	0.02125	0.02175	0.02225	"	"	0.02125	0.022
	3	0.0215	0.0215	0.022	"	"	0.0215	0.022
3.4	1	0.022	0.0235	0.023	0.022	0.0215	0.0215	0.0223
	2	"	0.02325	"	"	0.022	"	0.0223
3.5	1	0.022	0.0215	0.0215	0.0225	0.0235	0.0225	0.0223
3.6	1	0.023	0.0215	0.0215	0.022	0.0225	0.023	0.0223
3.7	1	0.0215	0.02175	0.023	0.023	0.022	0.0215	0.0221
3.8	1	0.0225	0.0215	0.0215	0.0215	0.022	0.023	0.022
3.9	1	0.022	0.02275	0.023	0.022	0.0215	0.0215	0.0221
3.10	1	0.0225	0.023	0.022	0.0215	0.0215	0.0215	0.022
3.11	1	0.021	0.021	0.022	0.023	0.023	0.022	0.022
3.12	1	0.0215	0.023	0.023	0.022	0.0215	0.0215	0.0221
3.13	1	0.023	0.023	0.0215	0.0215	0.022	0.022	0.0221
3.14	1	0.02125	0.0215	0.02175	0.02225	0.023	0.02225	0.022

APPENDIX IN (Contd)

Ovality of 1" Dia. x 24 S.W.G. Brass Tubing - Set 1

Tube No.	Station	Maximum	Position	Minimum	Position
1.1	1	+4	A-D	+3	E-B
	2	+5	E-B	+2.5	F-C
	3	+7.5	A-D	+2	F-C
	4	+4.5	E-B	+2.5	F-C
	5	+5	E-B	+2.5	F-C
	6	+5	E-B	+2.5	F-C
	7	+5	E-B	+2.5	F-C
	8	+4	A-D	+3.5	F-C
1.2	1	+5	F-C	+3	B-E
	2	+5	F-C	+2	B-E
	3	+4.5	F-C	+3	B-E
1.3	1	+4	F-C	+3.5	B-E
	2	+4.5	F-C	+1.5	B-E
	3	+5	A-D	+2	B-E
1.4	1	+4	A-D	+2.5	B-E
	2	+5	F-C	+2	A-D
1.5	1	+4	F-C	+3	B-E
1.6	1	+4.5	A-D	+2	B-E
1.7	1	+5	A-D	+1.5	F-C
1.8	1	+4.5	B-E	+2	F-C
1.9	1	+4	A-D	+3	B-E
1.10	1	+4	B-E	+2	A-D
1.11	1	+4.5	F-C	+2	A-D
1.12	1	+3.5	A-D	+2	B-E
1.13	1	+4	A-D	+1	B-E
1.14	1	+4	A-D	+1	B-E

Ovality of 1" Dia. × 24 S.W.G. Brass Tubing - Set 2

Tube.No.	Station	Maximum	Position	Minimum	Position
2.1	1	+5	A-D	+1.5	C-F
	2	+4	A-D	+2	B-E
	3	+4	C-F	+3	B-E
	4	+4	C-F	+2.5	B-E
	5	+3.5	C-F	+3	B-E
	6	+4.5	C-F	+2	B-E
	7	+4.5	C-F	+2.5	B-E
	8	+5	B-E	+2	A-D
2.2	1	+4.5	A-D	+2	C-F
	2	+4.5	A-D	+2	B-E
	3	+8	C-F	-4	A-D
2.3	1	+4	A-D	+2	C-F
	2	+5	B-E	+1.5	C-F
	3	+5	C-F	+1.5	A-D
2.4	1	+3	A-D	+2.5	C-F
	2	+3.5	A-D	+3	C-F
2.5	1	+3	A-D	+2.5	B-E
2.6	1	+3	A-D	+2	C-F
2.7	1	+3	-	+3	-
2.8	1	+3	A-D	+2	B-E
2.9	1	+3	F-C	+2	B-E
2.10	1	+3	B-E	+1.5	A-D
2.11	1	+3	F-C	+1.5	A-D
2.12	1	+4	A-D	+1.5	B-E
2.13	1	+3	F-C	+1	A-D
2.14	1	+3	F-C	+1	B-E

APPENDIX IN (Contd)

Ovality of 1" Dia. × 24 S.W.G. Brass Tubing - Set 3

Tube No.	Station	Maximum	Position	Minimum	Position
3.1	1	+4	B-E	+2	C-F
	2	+4	C-F	+2	A-D
	3	+4.5	"	+2	A-D
	4	+4.5	"	+2	A-D
	5	+5	"	+2	E-B
	6	+4.5	"	+2.5	E-B
	7	+5	"	+2	E-B
	8	+4	"	+3	A-D
3.2	1	+5	A-D	+2	C-F
	2	+5	E-B	+1	C-F
	3	+4	C-F	+2.5	A-D
3.3	1	+5	A-D	+2.5	C-F
	2	+5	B-E	+1	C-F
	3	+4.5	A-D	+2	E-B
3.4	1	+5	B-E	+1.5	C-F
	2	+4	B-E	+2.5	C-F
3.5	1	+4	A-D	+2	C-F
3.6	1	+4	A-D	+2.5	B-E
3.7	1	+3	A-D	+1.5	B-E
3.8	1	+4	C-F	+2.5	B-E
3.9	1	+4	C-F	+2	B-E
3.10	1	+4.5	C-F	+1	A-D
3.11	1	+4	B-E	+2	C-F
3.12	1	+4.5	B-E	+2	A-D
3.13	1	+3.5	B-E	+2	A-D
3.14	1	+3	B-E	+2	A-D

APPENDIX IV (Contd)

Mechanical Properties of 1" Dia. × 24 S.W.G. Brass Tubing

Grain Direction	E × 10^{-6} lb/in^2	L.P.	0.1% P.S.	0.2% P.S.	0.5% P.S.	Max. Stress	Elongation % on 1"
Longitudinal	15.4	8.5	23.4	28.3	33.8	37.4	7.0
Transverse	15.1	9.6	28.5	32.2	35.2	36.4	7.0

Relation between Mechanical and Pressure Test Specimens

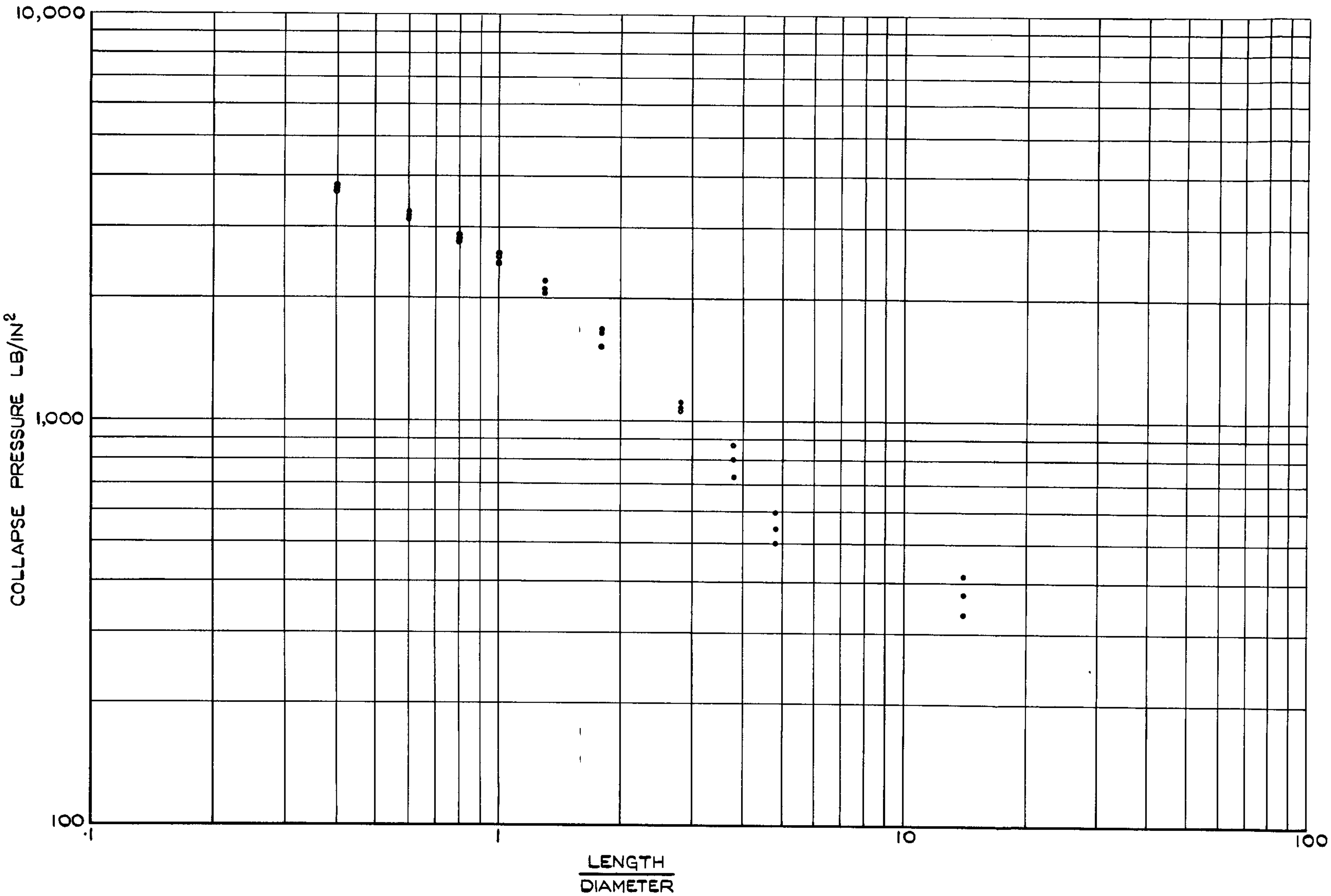
All Pressure Test specimens were cut from one length of tube, and the results quoted above were therefore applied to all Pressure Test Specimens.

APPENDIX IN (Contd)

Results of Tests on 1" Dia. x 24 S.W.G. Brass Tubing under Uniform External Pressure Applied to the Sides Only

Tube No.	Collapse Pressure	$\frac{L}{D}$	No. Lobes Formed	Estimated No. Lobes in Complete Periphery
1.1	335	14	2	2
2.1	415	"	2	2
3.1	375	"	2	2
1.2	500	4.8	2	2
2.2	595	"	2	2
3.2	540	"	2	2
1.3	725	3.8	2	2
2.3	870	"	2	2
3.3	800	"	2	2
1.4	1125	2.8	3	3
2.4	1230	"	2	2
3.4	1160	"	3	3
1.5	1525	1.8	3	3
2.5	1680	"	3	3
3.5	1650	"	3	3
1.6	2060	1.3	4	4
2.6	2100	"	4	4
3.6	2200	"	4	4
1.7	2450	1.0	4	4
2.7	2580	"	4	4
3.7	2520	"	4	4
1.8	2780	0.8	4	4
2.8	2850	"	4	4
3.8	2820	"	4	4
1.9	3200	0.6	3	4
2.9	3230	0.6	4	5
3.9	3120	0.6	3	5
1.10	3750	0.4	4	6
2.10	3800	"	3	6
3.10	3680	"	4	5

Attached: Drg. SME.75215/R



RESULTS OF TESTS ON 1" DIA. x 24 S.W.G. BRASS TUBING UNDER UNIFORM EXTERNAL PRESSURE APPLIED TO THE SIDES ONLY.

APPENDIX IO

Control Tests on Tubular Specimens

Details of Specimen Sizes

Material	Specimen No.	Width	Thickness	Area
2¼" o/d x 24 SWG x T45	1L2	0.1893	0.0269	0.00509
	2L1	0.1867	0.026	0.00485
	3L1	0.1871	0.024	0.00449
	4L1	0.1874	0.0287	0.005378
	5L2	0.1874	0.023	0.00431
	6L1	0.1845	0.227	0.00418
	7L1	0.1894	0.024	0.004545
1.75" o/d x 22 SWG x T45	1E1	0.2513	0.0312	0.00738
	1E2	0.2512	0.0287	0.0072
	2E1	0.2484	0.0306	0.0076
	2M	0.2492	0.0296	0.00737
	3E1	0.25	0.0304	0.00759
	4E1	0.2498	0.0271	0.00673
	4E2	0.248	0.0292	0.00724
	5E1	0.2507	0.0276	0.00692
	6E1	0.2512	0.0277	0.00696
	7E1	0.2505	0.0304	0.00762
	8E1	0.249	0.0298	0.00742
1" Dia x 24 SWG x T45	1	0.1897	0.0242	0.00458
	2	0.1884	0.0241	0.00454
	3	0.1898	0.0237	0.0045
1" Dia x 22 SWG x T45	1	0.1898	0.0305	0.00578
	2	0.1881	0.0317	0.00596
	3	0.1868	0.0324	0.00605
1" Dia x 20 SWG x T45	1	0.189	0.0392	0.0074
	2	0.188	0.0407	0.00764
	3	0.1887	0.0410	0.00773
1" Dia x 17 SWG x T45	1	0.1876	0.0537	0.01008
	2	0.1869	0.0584	0.0109
1" Dia x 24 SWG				
DTD 305	1	0.1877	0.02506	0.0047
T55	1	0.1874	0.0228	0.00427
T26	1	0.1893	0.0236	0.00446
DTD 102A	1	0.189	0.0246	0.004645
T58	1	0.1903	0.0242	0.0046
DTD 460	A1	0.1865	0.0227	0.00423
	B1	0.1874	0.023	0.00431
Brass	1	0.1882	0.0222	0.00418

APPENDIX 10 (Contd)

2¼" o/d x T45 x 24 SWG Tube

Longitudinal Test Results

Load lbs	1L2	2L1	3L1	4L1	5L2	6L1	7L1
10		0	0	0	0	0	0
20	0	26	17	16.5	0	24	19
30	11.5	49	33.5	29	14.5	39	39
40	22	68	49	45	29	51	58
50	32	83	63	57	42	71	72
60	43	96	76	68	56	83	88
70	54	112	90	78	70	98	110
80	64.5	127	103	89	84	112	113.5
90	75.5	141	116	99	98	125	126
100	86	155	128.5	110	112	138	139
110	97	168	142	120	125.5	151	151
120	108	181	155	131	139	164	162
130	119	193	168	141	152	176	173
140	130	204	180	152	164.5	189	186
150	140.5	216	191	162	177	201	198
160	152	228	203	172	190	214	209
170	163	238	216	182	203	227	221
180	174	249	228	192	216.5	239	232
190	184	261	241	203	230	252	245
200	196	272	253	213.5	243	266	257
210	207	283.5	266	224	256	279	269
220	218	294	279	234	269.6	293	281
230	229	305	292	244	283	306	294
240	240	316	303.5	255	296	320	307
250	251	327	317	266	309	334	319
260	262	338	329	276	323	348	332
270	272	349	341	286	336	363	344
280	283	359	352	297	350	378	356
290	294	370	364	308	363	393	368
300	305	380	376	318	377	410	380
310	316	390	389	328	391	426	393
320	326.5	401	401	339	406	442	405
330	338	411	414	351	419	460	417
340	348.5	422	427	361	433	479	430
350	360	432	441	372	447	499	443
360	371	443	455	383	461	520	457
370	383	454	469	394	476.5	545	470
380	394	466	483	404	492	574	484
390	405	477.5	497	415	511	612	500
400	417	490	512	425	536	670	516
410	428	507	528	436	574	800	535
420	440	531	537	447	663		559
430	453	630	546	457	910		589
440	465		556	468			634
450	478		566	481			715
460	494		583				768
470	523		607	495			860
480			664	515			1020

1.75" Dia x 22 SWG x T45

Longitudinal Test Results

Load	1E1	2E1	2M1	3E1	4E1	4E2	7E1
50	0	0	0	0	0	0	0
100	36	34.5	36	33.8	36	37	36
150	71	69	73	67.5	78	77	72
200	106	103	110	104	120	104	107
250	141	138	147.5	141	161	153	141
300	177.5	173	185	177	201	191	175
350	213	210	222	213	241	228.5	210
400	248.5	246	259	249	280	256	246
450	285	284	296.4	286	319	305	281
500	322	323	334	323	360	344	319
510	329	-	342	332	369.8	352	327
520	337	340	351	339	378	360	334
530	344	349	359	347	389	369	341
540	351	357	367	356	399	377	349
550	359	366	375	363	409	386	357
560	367	375	383	370	421	395	364
570	375	384	391	378	433	405	371
580	383	393	399	386	452	416	379
590	391	402	407	394	478	428	387
600	398.5	412	415	402	530	442	394
610	406	423	423	410	740	462	403
620	413.6	433	432	418		493	415.4
630	422	444	440	427		590	419
640	429	455	449	435		760	427
650	438	468	459	443			436
660	446	481	469	453			446
670	455	497	480	462			455
680	464	513	493	472			465
690	474	533	509	485			475
700	485	561	531	503			487
710	498	596	581	525			499
720	514	650	780	571			511
730	534	721	1067	670			526
740	558	805		970			546
750	600	922					568
760	682	971					610
770	792	1052					675
780		1181					780
790		1300					930
800							1110
810							1440
820							
830							
840							
850							

Load	5E1	6E1	8E1
20	0	0	10
40	13	16	25
60	30	30	40
80	43	46	55
100	59	62	69
120	73	79	82
140	88	96	96
160	101	112	109
180	115	128	123
200	130	144	136
220	144	160	150
240	158	177	165
260	173	193	180
280	187	210	193
300	203	226	208
320	216	243	222
340	232	260	237
360	246	275	251
380	262	291	264
400	277	308	278
420	293	325	292
440	307	342	307
460	323	359	322
480	338	375	336
500	354	393	351
520	369	408	364
540	384	426	380
560	400	444	395
580	417	464	409
600	434	486	424
620	451	511	438
640	469	545	452
660	489	609	468
680	511	690	482
700	535	840	498
720	562		512
740	596		532
760	640		55
780	705		614
800	829		789
820	990		
840	1480		

APPENDIX IO (Contd)

1" Dia x 24 SWG x T45

Longitudinal Tests

Load	Specimen No. 1	2	3
10	0	0	0
20	10	13	11
30	21	23	23
40	33	33.5	36.5
50	44.6	45.5	48
60	56.6	57	60.5
70	69	69.2	71.8
80	81	85	83
90	93	96	92.2
100	105	108	105
110	116.7	121	118
120	128	134	129.5
130	140	145	141
140	152	157.5	153
150	164	169	164.3
160	176	180.4	177
170	188	192.5	189
180	199.8	205	201
190	212	218	212
200	224	231	224
210	236	244	238
220	248	256	249
230	260	268	261
240	271.6	279	273
250	283	291	284
260	295.6	303	296.4
270	307	315	309
280	319	329	321
290	332	341	333
300	344	354	345
310	357	366	358
320	369	378	371
330	382.5	391	383.5
340	393	404	396
350	409	417	409
360	421	431	422.5
370	434	445	435
380	448	459	449
390	462	472	462
400	477	488	476
410	492	503	490
420	503	517	504
430	525	536	520
440	544	557	536
450	569	583	554
460	602	631	578
470	666	731	611
480	727	825	692

1" Dia x 22 SWG x T45

Longitudinal Results

Load	Specimen No. 1	2	3
25	0	0	0
50	20	16	25
75	43	38	50
100	66	61	74
125	89	84	98
150	112	107	122
175	135	131	146
200	158	155	171
225	182.5	178	194
250	207	200	218
275	231	224	242
300	254	247	265
325	278	271	288
350	302	293	311
375	326	316	334
400	350	338	357
425	375	361	380
450	399	384	404
475	424.5	407	427
500	451	421	451
525	478	455	475
550	510	479	500
575	560	491	528
600		503	565
625		517	634
650		530	713
675		546	
700		564	
725		590	
750		630	
775		720	
800			
825			

1" Dia x 20 SWG x T45

Longitudinal Results

Load	Specimen No. 1	2	3
25	0	0	0
50	18	23	18
75	37	41	37
100	55	59	55
125	75	77	73
150	94	95	91
175	113	113	109
200	132	130	127
225	151.5	147.5	145
250	172	165	163
275	191	183	182
300	210	201	200
325	229	218.5	219
350	249	235	237
375	268	253	255
400	287	271	273
425	307	289	291
450	327	307	310
475	347	325	328
500	365	344	346
525	386	362	364
550	406	381	384
575	425	398	402
600	447	417	421
625	470	435	441
650	494	454	460
675	519	474	481
700	552	494	504
725	604	514	531
750	770	538	573
775		561	674
800		589	
825		640	

1" Dia x 17 SWG x T45

Longitudinal Results

Load	Specimen No. 1	2
50	0	0
100	25	20
150	50	45
200	75.5	69
250	101	93
300	126	117
350	151.5	140
400	177	164
450	202	189
500	227	213
550	253	238
600	278	262
650	303	287
700	328.5	312
750	354	336
800	381	361
850	406	387
900	432	417
950	462	460
1000	516	
1050	1500	

Load	DTD 305	T55	T26	DTD 102A	T58	Brass	DTD 460		
							Load	A1	B1
10	0	0	0	0	0	0	5	0	0
20	18	14	11.8	16	15.4	23	10	21	15
30	32	28	25	29	29	42	15	41	31.5
40	45	41.5	37.5	42	43	68	20	61	48.6
50	56	54	51	54.5	57	92	25	80.6	66.2
60	68	67.4	65	65.4	70	116	30	99	83.5
70	80	81	78	77	82	141	35	121	101.5
80	92	95	91.2	88	94	166	40	138	119
90	104	111	104	99	106	193	45	158	137
100	116	127	118	111	118	221	50	177	154
110	127.5	149	131	122.5	130	250	55	196	171.5
120	139.6	171	145.8	134	142	279	60	215	189.5
130	151	195	159	145	154	309	65	234	207
140	163	226	174	156	167	341	70	253	225
150	175	264	188	168	180	374	75	272	242
160	187	314	203	179	192.5	412	80	290	259.5
170	199	380	218	191	206	448	85	310	278
180	211	463	233	203	219	490	90	328	295.5
190	223	594	249	215	232	533	95	347	314
200	234	744	266	228	345	578	100	366	331
210	246	968	286	240	258	628	105	386	349.5
220	258	1240	400	254	272	682	110	405	369
230	269		650	267	285	736	115	424.5	387
240	281		1170	284	298	795	120	444	405
250	293			300	311.7	861	125	464	423.5
260	306			320	325	928	130	484	442
270	318			343	339	988	135	504	461
280	330			367	352	1051	140	524	480
290	343			400	367	1142	145	546	501
300	356			443	381	1260	150	567	519
310	371			511	395	1340	155	589	539
320	386			608	411	1410	160	611	559
330	403			757	426		165	637	580
340	425			978	442		170	659	602
350	456			1268	459		175	684	624
360	507				476		180	711	647
370	730				494		185	740	669
380					513		190	772	696
390					532		195	811	724
400					553		200	853	755
410					574		205	904	791
420					596		210	961	833
430					621		215	1042	884
440					647		220	1148	934
450					677		225	1301	1006
460					709		230	1485	1100
470					755		235		1222
480					785		240		1420
490					831				
500					881				
510					940				
520					1020				
530					1110				
540					1230				
550					1400				

APPENDIX IP

Dimensions of Control Test Specimens

Material	Specimen number	Width	Thickness	Area
$1\frac{3}{4}$" dia. × 24 swg × T45	E1	0.2461	0.0307	0.00756
	M1	0.2498	0.0296	0.00739
	E3	0.2487	0.0289	0.00718
1" dia. × 24 swg × T45	E1	0.251	0.0237	0.00595
	M1	0.2516	0.024	0.00603
	E3	0.249	0.0238	0.00593
1" dia. × 20 swg × T45	E1	0.2502	0.0393	0.0983
	M1	0.2503	0.0368	0.0921
	E3	0.2499	0.0384	0.096
$1\frac{1}{4}$" dia. × 17 swg × T26	E1	0.2506	0.0584	0.01464
	M1	0.2484	0.0572	0.0142
	E2	0.2441	0.0589	0.01439
1" dia. × 17 swg × T45	E1	0.251	0.0586	0.0147
	M1	0.2516	0.0556	0.0140
	E2	0.2484	0.0571	0.01418

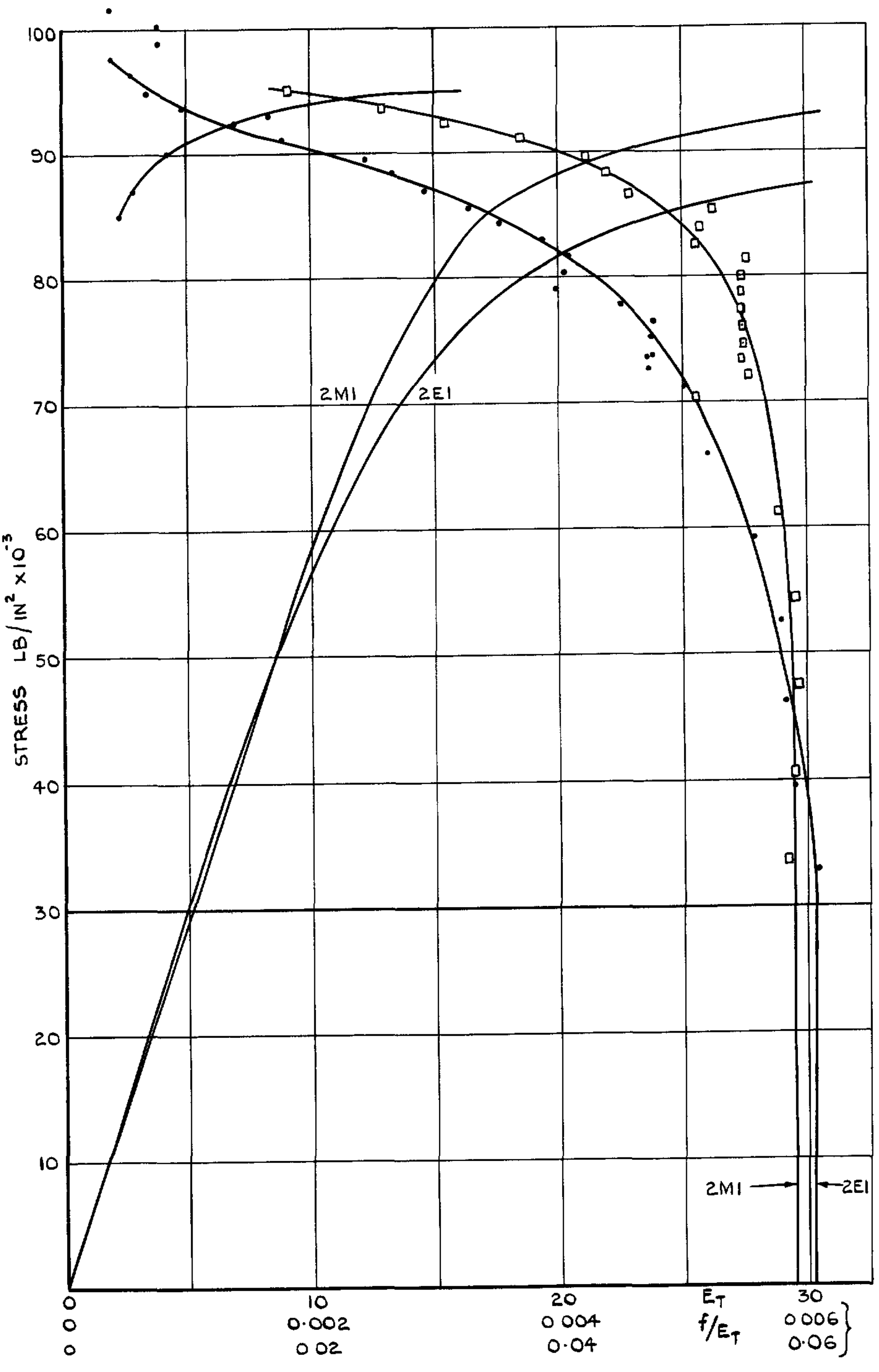
APPENDIX IP (Contd)

Load Extension Readings for Tangent Modulus Control Tests

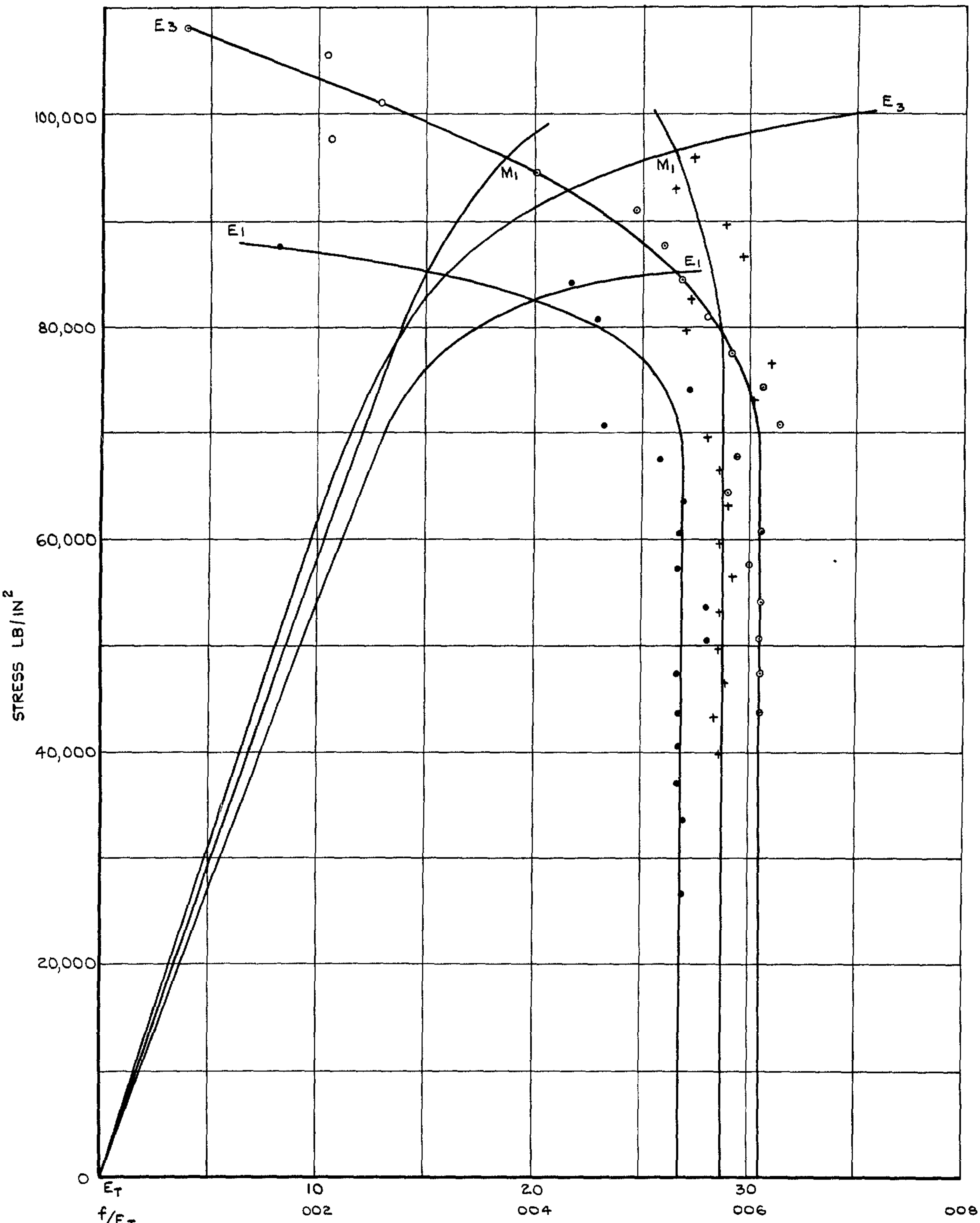
Load lbs	1¾" × 24 swg × T45			1" × 20 swg × T45			1" dia × 24 swg × T45		
	E1	M1	E3	E1	M1	E3	E1	M1	E3
20		0	0	0	0	0	0	0	0
40	8	11	8.8	7			13.3	11	11.8
60	15	22.2	17.8	14			27.2	24	24.2
80	23.8	31.8	27	21	14.7	24.8	40.3	34	35
100	32	41	36.4	28			53	45.4	45.8
120	40	51.8	45.2	34	29.2	29.6	67	58	57
140	48	60.4	54	41.5			79.4	69	68
160	56	69.6	63	48.8	44	42.3	92	80	79
180	64.7	78.5	72.5	55			105	91.5	90.6
200	73.5	87.2	81.8	63	59.6	58	118	103	102
220	82.8	96.5	91	68.7			130	114	113.5
240	90	105.8	100	75.2	74.5	71.8	143	125	124
260	98.9	115	109.2	82			153	137	135
280	107.5	124.3	119	89.3	90	86	168	148.5	146
300	116	133	128	95.4			180	160	157
320	124.8	142.2	137	102.5	102.5	101	192	171.5	168
340	133.8	151.1	146.8	109			204	183	179
360	142.7	160	156	116	120.3	116	217	194.2	190.3
380	151.8	169.2	165	123			229	206	201.2
400	161	178.5	175	129.7	136	131	242	217	213.3
420	170	188	184	136.5			255	229	224
440	179	197	193.4	143	151	146	270	240.3	235
460	188	206	203	150			280	251	246
480	196	214.9	212.6	157	167	160	294	262	258
500	205	224	222.4	164			309	275	270
520	214	234	233	170.6	182	175	326	286	283
540	223	242.5	243	177			351	297.5	296
560	231.4	251	254	184	198	191	581	309	311
580	241	261	264	191				322	331
600	250	270.5	275.3	198	214	206		333	364
620	258	280	286	204				345	387
640	268	288	297.6	211	230	221		358	446
660	275	297.5	310	218					602
680	285	307.4	324	224.6	246	235			1051
700	293	316.5	341	231					1540
720	302	326	368	238	264	251			
740	311	336	405	244					
760	319	347	471	252	286	267			
780	331	359	672	258					
800	471	392	1110	265.4	325	286			
820		1170		273	431				
840				281		319			
860				291		581			
880				302.5					
900				318					
920				359					
940				1040					

Load	1¼ × 17 swg × T26			1" × 17 swg × T45		
	E1	M1	E2	E1	M1	E1
40	0	0	0	0	0	0
80	10.0	9.2	10	9.7	9.2	8.8
120	20.3	18.3	21.6	19.0	17.8	17.4
160	29.5	27.7	30	27.8	26	27
200	39.7	37.5	40.3	37	34.8	36.5
240	49.5	47	50.5	45.4	43.8	45.4
280	60.2	56.8	60.5	55	53	55
320	70.5	66.8	70.5	64	62	64.3
360	80.8	77	81	72.8	71.3	73.5
400	91.3	87	91.5	82.2	80.4	82
440	102.2	97.2	102.2	91	89.7	91
480	113.3	108	113	100.8	99	100
520	125.2	119	124	110	108	109.6
560	137.2	130.6	135	119.2	117	118.2
600	149.9	143	146.9	128.6	127	127.5
640	163	156	159.4	137.7	136	136
680	177	170	171	146.8	145.4	146
720	192.7	185.6	184	156.4	155	155.4
760	210.3	203	199	166	164	164.6
800	233	225	214.5	175.3	173.8	174
840	260	251	231.5	185	183.5	183.5
880	293	285	251.5	194.7	193	192
920	337	332	276	204	203	201
960	407	401	307	214	212	211
1000	460	591	357	224.3	222.2	221
1040	561	760	407	237	232	230
1080	821	>1500	561	247	242	239
1120	1500			262	252	249
1160				287	262.5	258
1200					274	268
1240					281	278
1280					287	291
1320					294	312
1360					303	425
1400					312	
1440					325	
1480					344	
1520					400	
1560					502	
1600					731	
1640					1098	

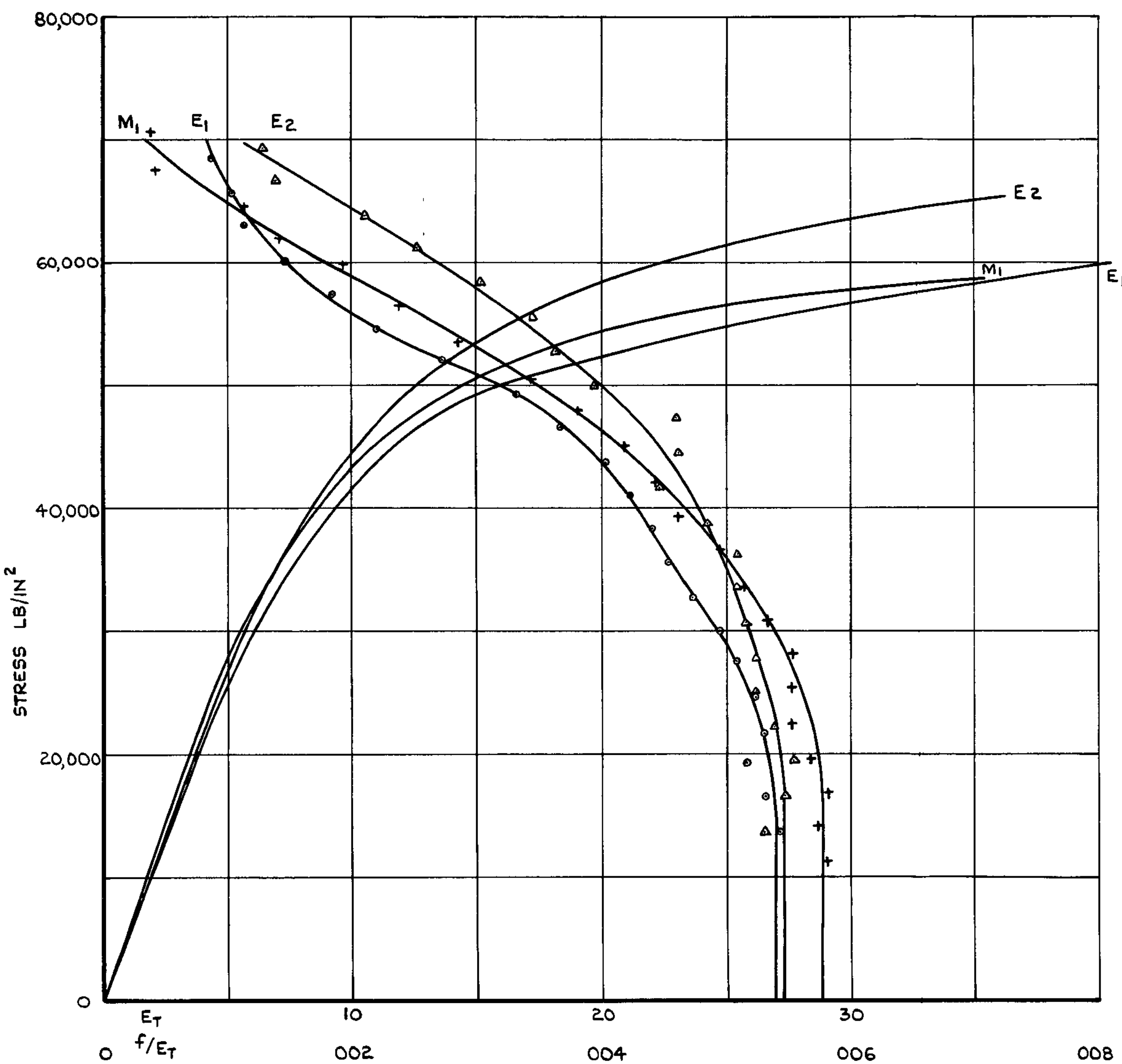
76998.



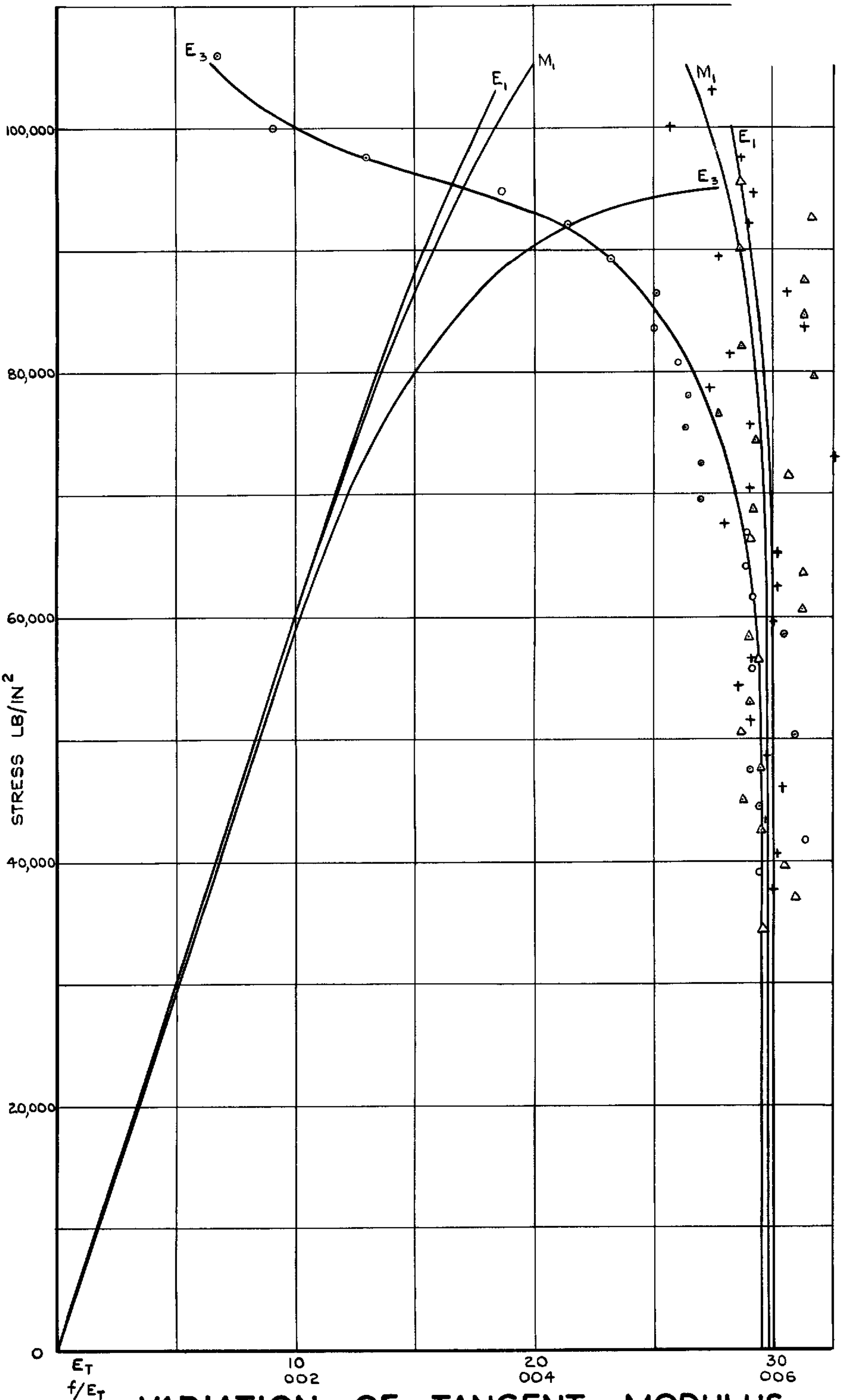
VARIATION OF TANGENT MODULUS FOR
1·75" DIA. × 22 S.W.G. × T45.



VARIATION OF TANGENT MODULUS $1\frac{3}{4}''$ O/D × 24 S.W.G. × T45 STEEL TUBE.

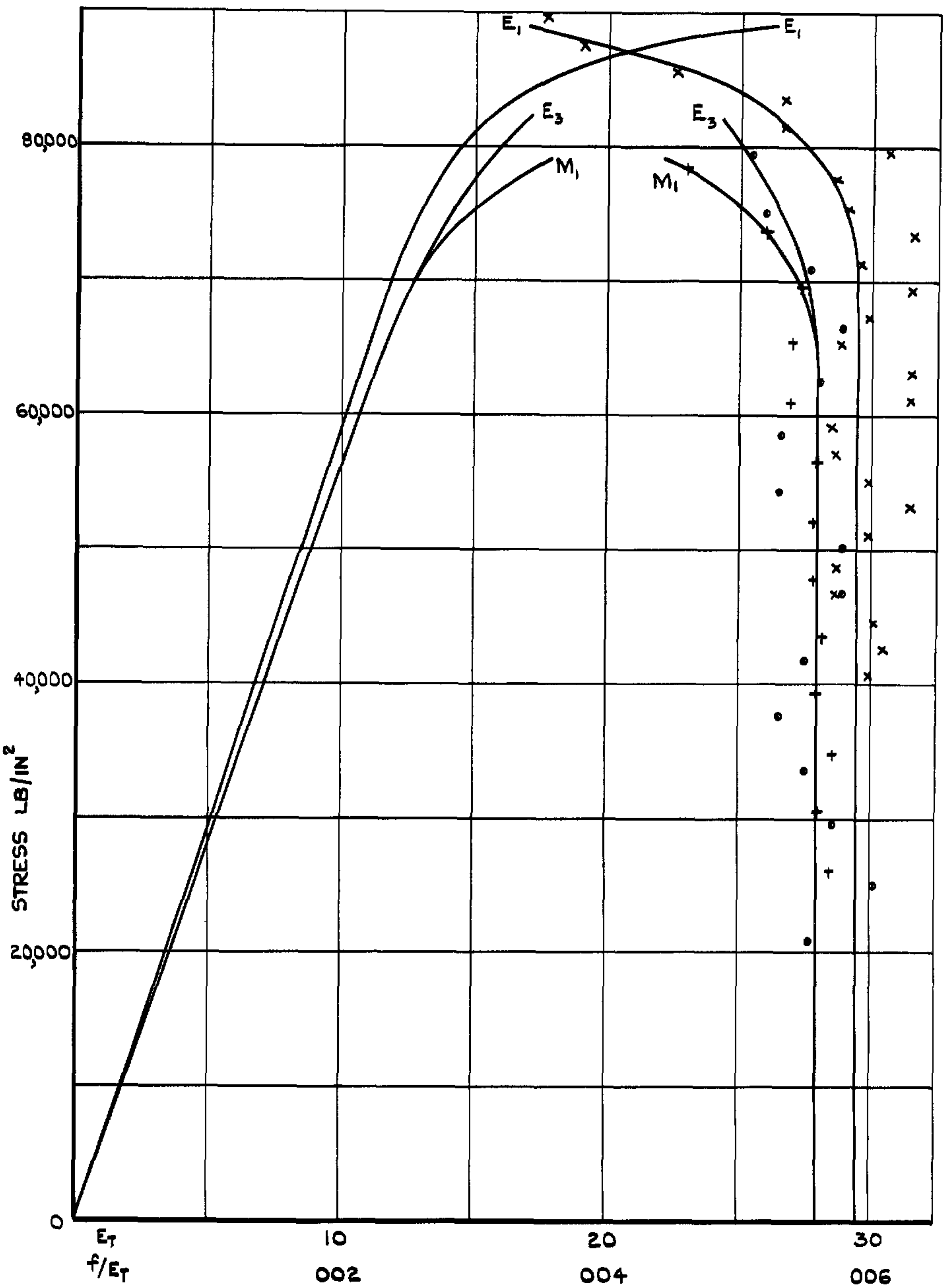


VARIATION OF TANGENT MODULUS $1\frac{1}{4}''$ DIA. × 17 S.W.G. × T 26 STEEL TUBES.



VARIATION OF TANGENT MODULUS FOR 1" DIA. × 24 S.W.G. × T45.

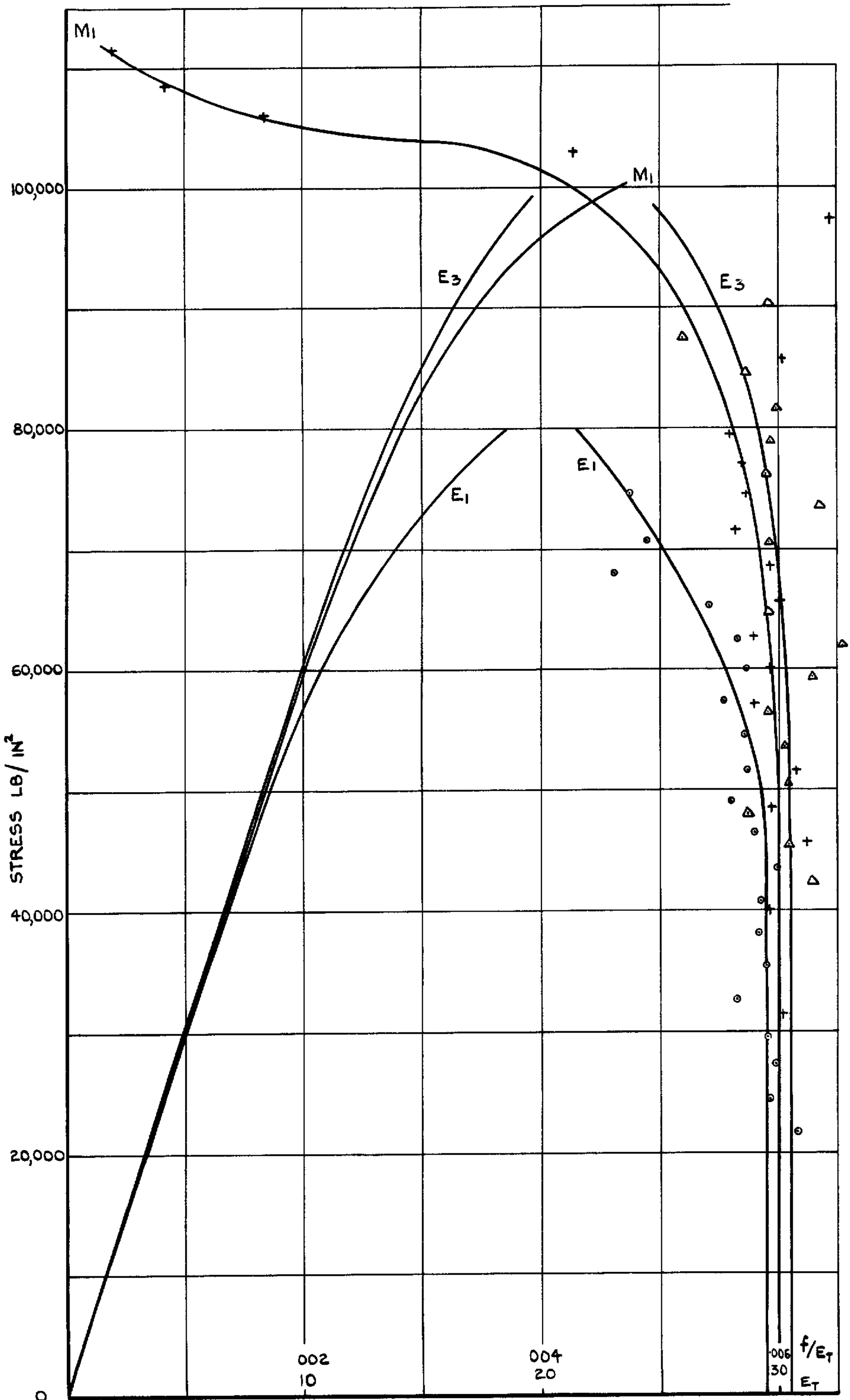
77001



VARIATION OF TANGENT MODULUS

1" DIA. × 20 S.W.G. × T45 STEEL TUBES.

77002



VARIATION OF TANGENT MODULUS FOR 1" DIA. 17 S.W.G. T45 TUBE.

APPENDIX II

The Evaluation of Tangent Moduli

The tangent moduli were determined mathematically from the 'five point' formula for numerical differentiation derived by Bickley[26].

For any five points y_0, y_1, y_2, y_3, y_4, the m^{th} differential of y ($m = 1, 2, 3, 4$) at the point $x = ra$ ($r = 0, 1, 2, 3, 4$) is given by the formula:-

$$\frac{a^m}{m} y^{(m)} = \frac{1}{4!} (A_0 y_0 + A_1 y_1 + A_2 y_2 + A_3 y_3 + A_4 y_4) \qquad (1)$$

For the case under consideration, $y_0 \ldots y_4$ represent extensometer scale readings recorded during the tensile tests, and the first differential only was required at the point $x = 2a$, where 'a' is the load increment. After substituting the appropriate values of $A_0 \ldots A_4$ for these conditions, equation (1) above reduces to:-

$$y = \frac{1}{a.4!} (2y_0 - 16y_1 + 16y_3 - 2y_4) \qquad (2)$$

Equation (2) was applied at successive steps of one load increment, the slope being determined at the centre of the five points considered in each case. In this context the formula determines the rate of change of extensometer reading with load. To obtain the tangent modulus the reciprocal of this result is multiplied by the factor $\dfrac{1}{\text{Area of specimens} \times \text{extensometer constant.}}$

Details of the load-extension readings are in Appendix I.

APPENDIX III

The Determination of Correction Factors for Measured Eccentricities of Bore

The stress distribution in an eccentrically bored tube under both internal and external pressure was determined theoretically by Jeffery[27]. In a subsequent paper[28], he computed the maximum wall stresses for wide ranges of D/t and eccentricity for the internal pressure case.

He defined the stress at any point on the internal surface of an eccentrically bored tube under external pressure by the equation:-

$$f = P\left[\frac{2r_2^2\ \{(r_2^2 - e^2)^2 - r_1^2\ (r_1 + 2\ e\ \cos\ \beta)^2\}}{(r_1^2 + r_2^2)\ \{r_2^2 - (r_1 - e)^2\}\ \{r_2^2 - (r_1 + e)^2\}}\right]$$

If the eccentricity is less than half the internal radius, the maximum stress occurs at $\beta = \pi$.

Using the following notation which is similar to that used in Jeffery's second paper[28],

$$\alpha = \frac{r_2 - r_1}{2r_2} = \frac{t}{D}$$

$$\beta = \frac{e}{(r_2 - r_1)} = \frac{e}{t}$$

Equation (1) above reduces to:-

$$f = P\left\{\frac{2\ [1 + (1 - 2\alpha)^2 - 4\alpha\beta\ (1 - 2\alpha) - 4\alpha^2\ \beta^2]}{[(1 - 2\alpha)^2 + 1]\ [1 - (1 - 2\alpha)^2 - 4\alpha\beta\ (1 - 2\alpha) - 4\alpha^2\ \beta^2]}\right\}$$

$$= \psi P.$$

The stress coefficient ψ was computed for $0.01 < \frac{t}{D} < 0.1$ and $0.00 < \frac{e}{t} < 0.12$, and for simplicity of application was reduced to non-dimensional form by the equation

$$\xi = \frac{P\psi}{\frac{PD}{2t}}$$

$$= \frac{2t}{D}\psi$$

The values of ξ and ψ for the range of $\frac{t}{D}$ and $\frac{e}{t}$ covered by the computation are shown in tabular form in Table XVIII and the variation of is presented graphically in Fig. 9.

Corrections for eccentricity effects were made by multiplying the value of $\frac{f}{E_t}$ calculated by Sturm and O'Brien's method by the non-dimensional coefficient ξ, determined for the measured eccentricities of each specimen. The factored tangent modulus was then read directly from the appropriate stress-tangent modulus - $\frac{f}{E_t}$ curve.

TABLE I

Summary of Material Specifications

	Tube Specification	T45	T55	T26	T58	DTD 102A	DTD 305	DTD 460
Mechanical Properties	0.1% Proof Stress	40	14	10.8	37	28	18	18
	0.2% Proof Stress	40	15	11	45	29	18	18.5
	0.5% Proof Stress	40	17	11.2	46	30.5	19	19
	Ultimate Stress	45	35	20	50	35	30	22
	E	28.5	27	29	25.5	29	29.5	10
Chemical Composition - %	Carbon	≯ 0.26	≯ 0.16	≯ 0.20	≯ 0.16	≯ 0.15	≯ 0.30	
	Silicon	0.05-0.35	≮ 0.20		≮ 0.20	≯ 0.50	≯ 0.35	
	Manganese	1.2-1.7	≯ 1.0		≯ 1.0	≯ 1.0	≯ 1.75	
	Sulphur	≯ 0.50	≯ 0.045	≯ 0.055	≯ 0.045	≯ 0.05	≯ 0.05	
	Phosphorous	≯ 0.50	≯ 0.045	≯ 0.050	≯ 0.045	≯ 0.05	≯ 0.05	
	Nickel	≯ 0.30	8-12		8-12	≯ 1.0	≯ 0.20	
	Chromium		16-20		16-20	≮ 12		
	Titanium*		≮ 0.80		≮ 0.80			
	Niobium*		≮ 1.60		≮ 1.6			

Titanium or Niobium shall be present as alternatives.

TABLE II

Collapse coefficients for Round Cylinders with Pressure Applied to the Sides Only, Ends Simply Supported

$D/t = 100$

L/R	N = 2	N = 3	N = 4	N = 5	N = 6	N = 7
40	2.23					
20	2.48					
16	2.87					
15	3.04					
12	4.19					
10	6.21	6.29				
9	8.20	6.49				
8		6.80				
7		7.36				
6		8.45				
5		10.86				
4.8			12.53			
4.5		13.19	12.88			
4.0			13.73			
3.5			15.26			
3.0			18.13			
2.9						
2.8						
2.7			21.16	21.81		
2.6				22.31		
2.5			24.17	22.9		
2.4				23.61		
2.3						
2.2				25.42		
2.1						
2.0				28.09		
1.9				29.9		
1.8				32.14		
1.7				34.96	35.16	
1.6				43.15	36.93	
1.5					39.19	
1.4					42.13	
1.3					46.03	
1.2					51.27	52.19
1.1					58.47	56.6
1.0						62.8
0.95						
0.90						71.79
0.85						
0.80						
0.75						
0.70						
0.65						
0.60						

TABLE II (Contd)

$^{D}/_{t} = 85$

$^{L}/_{R}$	N = 2	N = 3	N = 4	N = 5	N = 6	N = 7
40	2.22					
20	2.41					
16	2.70					
15	2.83					
12	3.67					
10	5.13	6.21				
9	6.58	6.36				
8	9.06	6.60				
7		7.03				
6		7.84				
5		9.64				
4.8						
4.5		11.36	12.55			
4.0		14.22	13.22			
3.5			14.41			
3.0			16.61			
2.9						
2.8						
2.7			18.91			
2.6						
2.5			21.18	22.09		
2.4			22.65	22.66		
2.3						
2.2				24.11		
2.1						
2.0				26.23		
1.9				27.65		
1.8				29.41		
1.7				31.62		
1.6				34.42	35.45	
1.5				37.99	37.32	
1.4					39.74	
1.3					42.94	
1.2					47.21	
1.1					53.06	54.24
1.0					61.25	59.56
0.95						
0.90						67.21
0.85						
0.80						78.64
0.75						
0.70						96.44
0.65						
0.60						125.64

TABLE II (Contd)

$D/t = 70$

L/R	N = 2	N = 3	N = 4	N = 5	N = 6	N = 7
40	2.22					
20	2.35					
16	2.56					
15	2.64					
12	3.23					
10	4.23					
9	5.22	6.26				
8	6.92	6.44				
7		6.75				
6		7.33				
5		8.61				
4.8						
4.5		9.82				
4.0		11.83	12.8			
3.5		15.36	13.69			
3.0			15.33			
2.9						
2.8						
2.7			17.02			
2.6						
2.5			18.68			
2.4			19.74			
2.3						
2.2			22.51	23.00		
2.1						
2.0			26.55	24.66		
1.9				25.77		
1.8				27.13		
1.7				28.83		
1.6				30.96		
1.5				33.68	35.75	
1.4				39.2	37.74	
1.3				41.81	40.42	
1.2					43.81	
1.1					48.52	
1.0					55.10	56.84
0.95						
0.90					64.51	63.37
0.85						
0.80						73.09
0.75						
0.70						88.22
0.65						
0.60						113.17

TABLE II (Contd)

$D/t = 50$

L/R	N = 2	N = 3	N = 4	N = 5	N = 6	N = 7
40	2.21					
20	2.29					
16	2.41					
15	2.46					
12	2.77					
10	3.31					
9	3.83					
8	4.72					
7	6.32	6.46				
6	9.47	6.81				
5		7.55				
4.8						
4.5		8.24				
4.0		9.36				
3.5		11.31	12.96			
3.0		14.93	13.63			
2.9						
2.8						
2.7			15.08			
2.6						
2.5			16.10			
2.4			16.75			
2.3						
2.2			18.42			
2.1						
2.0			20.84			
1.9						
1.8			24.42	24.77		
1.7			26.86	25.94		
1.6			29.93	27.39		
1.5				29.22		
1.4				31.58		
1.3				34.64		
1.2				38.69	40.31	
1.1				44.24	43.85	
1.0					48.75	
0.95						
0.90					55.75	
0.85						
0.80					66.10	67.36
0.75					73.19	72.82
0.70						79.74
0.65						
0.60						100.3
0.50						

TABLE II (Contd)

$^{D}/_{t} = 40$

$^{L}/_{R}$	N = 2	N = 3	N = 4	N = 5	N = 6	N = 7
40	2.21					
20	2.27					
16	2.36					
15	2.39					
12	2.60					
10	2.96					
9	3.30					
8	3.89					
7	4.94	6.35				
6	7.00	6.61				
5		7.16				
4.8						
4.5		7.65				
4.0		8.44				
3.5		9.79				
3.0		12.28	13.52			
2.9						
2.8						
2.7		14.84	14.35			
2.6						
2.5		17.31	15.13			
2.4			15.63			
2.3						
2.2			16.89			
2.1						
2.0			18.7			
1.9						
1.8			21.35			
1.7						
1.6			25.39	26.05		
1.5			28.23	27.55		
1.4				29.47		
1.3				31.95		
1.2				35.22		
1.1				39.71		
1.0				45.72	46.38	
0.95						
0.90				54.34	52.46	
0.85						
0.80					61.47	
0.75						
0.70					75.5	76.56
0.65					85.54	85.13
0.60					98.82	95.47
0.50						130.28

TABLE II (Contd)

$D/t = 30$

L/R	N = 2	N = 3	N = 4	N = 5	N = 6	N = 7
40	2.21					
20	2.26					
16	2.31					
15	2.33					
12	2.47					
10	2.69					
9	2.89					
8	3.25					
7	3.88					
6	5.07	6.46				
5	7.64	6.84				
4.8						
4.5		7.18				
4.0		7.71				
3.5		8.61				
3.0		10.22				
2.9						
2.8						
2.7						
2.6						
2.5		13.40	14.38			
2.4			14.75			
2.3		15.53	15.19			
2.2			15.69			
2.1						
2.0			17.03			
1.9						
1.8			18.96			
1.7						
1.6			21.88			
1.5			23.91			
1.4			26.48			
1.3			29.81	29.85		
1.2				38.52		
1.1			39.94	36.18		
1.0				41.05		
0.95						
0.90				48.08	49.9	
0.85						
0.80				58.47	57.87	
0.75						
0.70					70.35	
0.65					79.38	
0.60					91.35	91.72
0.55						
0.50					130.60	124.48

TABLE II (Contd)

$D/t = 20$

L/R	N = 2	N = 3	N = 4	N = 5	N = 6	N = 7
40	2.21					
20	2.24					
16	2.28					
15	2.29					
12	2.38					
10	2.49					
9	2.6					
8	2.79					
7	3.11					
6	3.71					
5	4.95					
4.8	6.1	6.85				
4.5	7.94	7.2				
4.0		7.77				
3.5		8.75				
3.0						
2.9						
2.8						
2.7						
2.6						
2.5		10.62				
2.4						
2.3		11.85				
2.2		12.63				
2.1						
2.0		14.66	15.84			
1.9		15.98				
1.8		17.57	17.25			
1.7						
1.6			19.26			
1.5			20.82			
1.4			22.67			
1.3			25.04			
1.2						
1.1			32.34	33.65		
1.0			38.08	37.71		
0.95						
0.90				43.6		
0.85						
0.80				52.4		
0.75						
0.70				66.34	67.67	
0.65					74.96	
0.60				90.24	86.00	89.04
0.55						102.02
0.50					122.78	120.33
0.40						184.69

TABLE III

Master Charts for Estimating Collapse Pressure of Tubes Subjected to External Pressure Showing Calculated Values for Light Alloy Tubes to Specification D.T.D.460 (Specimen B.1)

1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
$\frac{t}{D}$	$\left(\frac{t}{D}\right)^2$	$\left(\frac{t}{D}\right)^3$	$\frac{L}{D}$	K	$\frac{f}{E_t} = \frac{K}{2}\left(\frac{t}{D}\right)^2$	E_t	P	$\frac{t}{D}$	$\left(\frac{t}{D}\right)^2$	$\left(\frac{t}{D}\right)^3$	$\frac{L}{D}$	K	$\frac{f}{E_t} = \frac{K}{2}\left(\frac{t}{D}\right)^2$	E_t	P
0.05	0.0025	0.000125	14	2.21	0.00276	10.23	2825	0.0143	0.000204	0.00000292	14	2.25	0.0002295	10.5	69
			12	2.21	0.00276	10.23	2825				12	2.27	0.000232	10.5	69.6
			10	2.24	0.0028	10.2	2855				10	2.34	0.000239	10.5	71.8
			8	2.28	0.00285	10.18	2900				8	1.56	0.000261	10.5	80
			6	2.38	0.002975	10.1	3000				6	3.23	0.00033	10.5	99
			4	2.8	0.0035	9.7	3395				4	6.43	0.000656	10.5	197
			3	3.72	0.00465	8.55	3970				3	7.35	0.00075	10.5	225
			2	7.2	0.009	5.3	4770				2	11.75	0.0012	10.5	360
			1.5	8.8	0.011	4.5	4890				1.5	15.2	0.00155	10.5	466
			1	14.8	0.0185	2.8	5175				1.0	24.5	0.0025	10.37	742
			0.8	19.26	0.0241	–	–				0.8	31.0	0.00316	9.96	901
0.033	0.00111	0.0000369	14	2.22	0.00123	10.5	860	0.01177	0.0001385	0.00000163	14	2.26	0.0001565	10.5	38.7
			12	2.23	0.00124	10.5	865				12	2.29	0.0001585	10.5	39.2
			10	2.26	0.001255	10.5	875				10	2.41	0.000167	10.5	41.2
			8	2.31	0.00128	10.5	895				8	2.7	0.000187	10.5	46.2
			6	2.47	0.00137	10.5	956				6	3.67	0.000252	10.5	62.7
			4	3.25	0.0018	10.5	1260				4	6.6	0.000457	10.5	113
			3	5.1	0.00283	10.2	1920				3	7.85	0.000844	10.5	134
			2	7.7	0.004275	8.9	2530				2	13.25	0.000916	10.5	226.5
			1.5	10.2	0.00566	6.0	2860				1.5	16.65	0.00115	10.5	285
			1	17.1	0.0095	5.0	3150				1.0	26.1	0.00181	10.5	446
			0.8	21.88	0.01215	4.1	3310				0.8	34.4	0.00238	10.43	589
0.025	0.000625	0.0000156	14	2.23	0.000697	10.5	365	0.01	0.0001	0.000001	14	2.26	0.000113	10.5	23.75
			12	2.23	0.000697	10.5	365				12	2.3	0.000115	10.5	24.15
			10	2.27	0.00071	10.5	372				10	2.48	0.000124	10.5	26
			8	2.36	0.000737	10.5	386				8	2.87	0.000144	10.5	30.15
			6	2.6	0.000812	10.5	426				6	4.19	0.00021	10.5	44
			4	3.9	0.00122	10.5	638				4	6.8	0.00034	10.5	71.5
			3	6.6	0.00206	10.5	1080				3	8.45	0.000422	10.5	88.6
			2	8.45	0.00264	10.3	1358				2	13.75	0.000687	10.5	144.4
			1.5	12.25	0.00383	9.37	1790				1.5	18.2	0.00091	10.5	191
			1	18.7	0.00585	7.35	2145				1	28	0.0014	10.5	294
			0.8	25.4	0.00795	5.9	2340				0.8	37	0.00185	10.5	389
0.02	0.0004	0.000008	14	2.22	0.000444	10.5	186.5								
			12	2.23	0.000446	10.5	187.5								
			10	2.29	0.000458	10.5	192.5								
			8	2.41	0.000482	10.5	202.5								
			6	2.77	0.000554	10.5	233								
			4	4.72	0.000944	10.5	397								
			3	6.8	0.00136	10.5	571								
			2	9.4	0.00188	10.5	790								
			1.5	14	0.0028	10.2	1175								
			1	20.8	0.00416	9.2	1530								
			0.8	27.4	0.00548	7.75	1700								

TABLE IV

Results of Tests on $2\frac{1}{4}$" Dia x 24 S.W.G. x T45 Steel Tubes compared with Collapse Pressures Predicted by Sturm Theory

Tube No.	$\frac{L}{D}$	Specimen No.	Actual Collapse lb/in.^{2}	Theoretical Collapse lb/in.^{2}	Difference	Percentage of Theoretical Value
1.1	14	1	110	100	+10	+10
2.1	-	4	115	105	+10	+9.5
1.3	12	2	127	135	+8	+5.92
2.3	-	6	115	116	Nil	Nil
1.4	10	1	125	130	-5	-3.85
2.4	-	5	93	92	+1	+1.09
1.6	8	3	115	120	-5	-4.16
2.6	-	6	133	139	-6	-4.32
1.7	6	2	192	195	+3	+1.54
2.7	-	6	178	195	-17	-8.72
1.8	4	3	278	300	-22	-7.33
2.8	-	5	250	248	+2	+0.8
1.9	2	3	560	570	-10	-1.76
2.9	-	6	625	700	-75	-10.7
1.10	1.5	3	725	750	-25	-5.34
2.10	-	6	780	880	-100	-11.5
1.11	1.0	1	1250	1400	-150	-10.7
2.11	-	5	995	1050	-55	-5.24
1.13	0.835	2	1610	1730	-120	-6.95
2.13	-	7	1250	1305	-55	-4.2
1.14	0.72	3	1440	1560	-120	-7.7
2.14	-	7	1510	1550	-40	-2.58
1.15	0.667	3	1690	1690	Nil	Nil
2.15	0.662	7	1760	1700	+60	+3.53
1.16	0.57	4	2100	2050	+50	+2.44
2.16	0.51	7	1990	1850	+140	+7.56

TABLE V

Results of Tests on $1\frac{3}{4}$" Dia × 22 S.W.G. × T45 Steel Tubes compared with Collapse Pressures Predicted by Sturm Theory

Tube No.	$\frac{L}{D}$	Specimen No.	Actual Collapse lb/in.^{2}	Theoretical Collapse lb/in.^{2}	Difference	Percentage of Theoretical Value
A1	14	1,2	-	-	-	-
B1	-	3,4,5	334	300/320	+14	+4.6
C1	-	6,7	339	285/310	+29	+9.38
A2	12	1,2	340	300/310	+30	+9.7
B2	-	3,4,5	342	315/340	+2	+0.59
C2	-	6,7	340	280/300	+40	+13.3
A3	10	1,2	367	340/360	+7	+1.94
B3	-	3,4,5	387	375/410	Nil	Nil
C3	-	6,7	300	275/295	+5	+1.7
A4	8	1,2	390	365/385	+5	+1.3
B4	-	3,4,5	396	395/420	Nil	Nil
C4	-	6,7	320	290/310	+10	+3.23
A5	6	1,2	425	430/440	-5	-1.16
B5	-	3,4,5	420	400/435	Nil	Nil
C5	-	6,7	433	390/415	+18	+4.34
A6	4	1,2	850	830/870	Nil	Nil
B6	-	3,4,5	715	650/705	+10	+1.42
C6	-	6,7	712	720/780	-8	-1.11
A7	2	1,2	1512	1520/1600	-8	-0.527
B7	-	3,4,5	1360	1400/1505	-40	-2.86
C7	-	6,7	1505	1460/1550	Nil	Nil
G4	1.0	1,2	2890	3300	-310	-9.4
G5	-	8	2420	3250	-830	-25.5
G6	-	8	2580	3250	-670	-20.6

TABLE VI

Results of Tests on 1" Dia x 24 S.W.G. x T45 Steel Tubes compared with Collapse Pressures Predicted by Sturm Theory

Tube No.	$\frac{L}{D}$	Specimen No.	Actual Collapse $lb/in.^2$	Theoretical Collapse $lb/in.^2$	Difference	Percentage of Theoretical Value
4.3	12.05	1-3	965	900-945	+20	+2.22
5.3	-	"	950	870-920	+30	+3.26
4.5	10.05	1-3	1020	960-1000	+20	+2
5.5	-	"	1015	900-940	+75	+7.98
4.7	8.05	1-3	1040	930-980	+60	+6.12
5.7	-	"	1033	920-960	+73	+7.6
6.2	5.8	1-3	1170	1060-1100	+70	+6.36
7.2	-	"	1180	1060-1100	+80	+7.27
1.2	4.1	1	1630	1600	+30	+1.88
2.2	-	2	1660	1630	+30	+1.85
3.2	-	3	1675	1600	+75	+4.69
1.3	3.05	1	2650	2610	+40	+1.53
2.3	-	2	2670	2700	-30	-1.11
3.3	-	3	2460	2620	-160	-6.13
6.3	2.3	1-3	3080	2950-3120	Nil	Nil
7.3	-	"	3080	2950-3120	Nil	Nil
1.4	1.55	1	4400	4000	+400	+9.1
2.4	-	2	4135	4100	+35	+8.53
1.5	1.0	1	5300	4350	+950	+21.8
2.5	-	2	5500	4600	+900	+19.6
3.5	-	3	4950	4700	+250	+5.32

TABLE VII

Results of Tests on 1" Dia x 22 S.W.G. x T45 Steel Tubes compared with Collapse Pressures Predicted by Sturm Theory

Tube No.	$\frac{L}{D}$	Specimen No.	Actual Collapse lb/in.^{2}	Theoretical Collapse lb/in.^{2}	Difference	Percentage of Theoretical Value
1.1	14	1	2210	2200	+10	+0.045
2.1	-	2	2280	2150	+130	+6.05
3.1	-	3	2090	1950	+140	+7.2
1.2	12	1	2110	2000	+110	+5.5
2.2	-	2	2310	2020	+290	+14.35
3.2	-	3	2070	1990	+80	+4.02
1.3	10	1	2090	2050	+40	+1.95
2.3	-	2	2300	2160	+140	+6.5
3.3	-	3	2120	2060	+60	+2.9
1.5	8	1	2120	2060	+60	+2.9
2.5	-	2	2330	2200	+130	+5.9
3.5	-	3	2150	2150	Nil	Nil
1.6	5.98	1	2240	2240	Nil	Nil
2.6	-	2	2450	2340	+110	+4.7
3.6	-	3	2270	2300	-30	-0.13
1.7	4	1	2865	3000	-135	-4.5
2.7	-	2	3200	3100	+100	+3.22
3.7	-	3	2860	3060	-200	-6.55
1.8	2	1	6225	-	-	-
2.8	-	2	6125	6300	-175	-2.78
3.8	-	3	5425	-	-	-

TABLE VIII

Results of Tests on 1" Dia x 20 S.W.G. x T45 Steel Tubes compared with Collapse Pressures Predicted by Sturm Theory

Tube No.	$\frac{L}{D}$	Specimen No.	Actual Collapse lb/in.^{2}	Theoretical Collapse lb/in.^{2}	Difference	Percentage of Theoretical Value
1.1	14	1	4575	4350	+225	+5.15
3.1	"	3	4575	4450	+125	+2.8
1.3	12	1	4575	4400	+175	+3.98
2.3	"	2	4525	4450	+75	+1.69
3.3	"	3	4525	4400	+125	+2.84
1.5	10	1	4675	4500	+175	+3.89
2.5	"	2	4475	4450	+25	+0.56
3.5	"	3	4625	4500	+125	+2.78
1.7	8	1	4675	4550	+125	+2.75
2.7	"	2	4565	4650	-85	-1.825
3.7	"	3	4500	4600	-100	-2.18
1.9	6	1	4925	4700	+225	+4.8
2.9	"	2	4925	4800	+125	+2.6
3.9	"	3	4825	4800	+25	+0.52
1.11	4	1	5905	5550	+355	+6.4
2.11	"	2	5700	5750	-50	-0.87
3.11	"	3	6100	5550	+550	+9.9
1.12	3	1	7400	7100	+300	+4.23
2.12	"	2	6600	7600	-1000	-13.15
3.12	"	3	7500	7150	+450	+6.3
1.14	2.0	1	9450	8000	+1450	
2.14	"	2	9200	-		
3.14	"	3	8400	-		

TABLE IX

Results of Tests on 1" Dia x 17 S.W.G. x T45 Steel Tubes compared with Collapse Pressures Predicted by Sturm Theory

Tube No.	L/D	Specimen No.	Actual Collapse lb/in.^{2}	Theoretical Collapse lb/in.^{2}	Difference	Percentage of Theoretical Value
1.1	14	1	11300	13000	-1700	-13.1
2.1	"	2	11200	12500	-1300	-10.4
3.1	"	2	11600	12500	-900	-7.2
1.2	12	1	12000	13000	-1000	-7.7
2.2	"	2	11200	12100	-900	-7.45
3.2	"	2	11500	12700	-1200	-9.45
1.3	10	1	12300	13000	-700	-5.4
2.3	"	2	11400	12700	-1300	-10.25
3.3	"	2	11750	12700	-950	-7.49
1.4	8	1	12800	13000	-200	-1.54
2.4	"	2	11800	12600	-800	-6.35
1.5	6	1	12500	13300	-800	-6
2.5	"	2	11700	12600	-900	-7.06
1.6	4	1	13400	13300	+100	+0.755
2.6	"	2	11500	12800	-1000	-7.9
3.6	"	1	12400	13500	-1100	-8.15

TABLE X

Results of Tests on 1" Dia x 24 S.W.G. x D.T.D. 305 Steel Tubes compared with Collapse Pressures Predicted by Sturm Theory

Tube No.	L/D	Actual Collapse lb/in.^{2}	Theoretical Collapse lb/in.^{2}	Difference	Percentage of Theoretical Value
1.1	14	760	820	-60	-7.32
2.1	"	780	890	-110	-12.3
3.1	"	830	920	-90	-9.78
1.2	4	1230	1600	-370	-23.1
2.2	"	1250	1650	-400	-24.2
3.2	"	1410	1650	-240	-14.55
1.3	3.0	1800	2400	-600	-25
2.3	"	1790	2400	-610	-25.4
3.3	"	2040	2400	-560	-23.35
1.5	2.0	1940	2930	-990	-33.8
2.5	"	2060	2900	-840	-29
3.5	"	2230	2930	-700	-23.9
1.6	1.5	2200	3280	-1080	-32.9
2.6	"	2260	3220	-960	-29.8
3.6	"	2500	3350	-850	-25.4
1.8	1.0	2730	3450	-720	-20.9
2.8	"	2625	3500	-875	-25
3.8	"	2920	3500	-580	-16.6

TABLE XI

Results of Tests on 1" Dia x 24 S.W.G. x T55 Steel Tubes compared with Collapse Pressures Predicted by Sturm Theory

Tube No.	$\frac{L}{D}$	Actual Collapse lb/in.^{2}	Theoretical Collapse lb/in.^{2}	Difference	Percentage of Theoretical Value
1.1	14	800	890	-90	-10.1
2.1	"	740	940	-200	-21.3
3.1	"	800	940	-140	-14.9
1.2	4	1150	1160	-10	-1.86
2.2	"	1250	1240	+10	+0.81
3.2	"	1140	1215	-75	-6.18
1.3	3	1520	1410	+110	+7.8
2.3	"	1520	1490	+30	+2.01
3.3	"	1310	1440	-130	-9.03
1.5	2	1740	1520	+220	+14.5
2.5	"	1720	1620	+100	+6.2
3.5	"	1860	1600	+260	+16.25
1.6	1.5	1970	1710	+260	+15.2
2.6	"	1920	1790	+130	+7.26
3.6	"	2300	1750	+550	+3.14
1.8	1.0	2270	1860	+410	+22
2.8	"	2150	1950	+700	+5.13
3.8	"	2300	1860	+440	+23.7

TABLE XII

Results of Tests on 1" Dia x 24 S.W.G. x T26 Steel Tubes compared with Collapse Pressures Predicted by Sturm Theory

Tube No.	$\frac{L}{D}$	Actual Collapse lb/in.^{2}	Theoretical Collapse lb/in.^{2}	Difference	Percentage of Theoretical Value
1.1	14	800	790	+10	+1.26
2.1	"	750	710	+40	+5.63
3.1	"	860	740	+120	+16.2
1.2	4	1180	1350	-170	-12.6
2.2	"	1410	1300	+110	+8.46
3.2	"	1330	1320	+10	+0.75
2.3	3	1750	1900	-150	-7.9
3.3	"	1730	1900	-170	-8.95
1.5	2	2000	2130	-130	-6.1
2.5	"	2300	2090	+210	+10
3.5	"	1970	2100	-130	-6.2
1.6	1.5	2550	2300	+250	+10.9
2.6	"	2250	2290	-40	-1.75
3.6	"	2100	2300	-200	-8.7

TABLE XIII

Results of Tests on 1" Dia × 24 S.W.G. × D.T.D. 102A Steel Tubes compared with Collapse Pressures Predicted by Sturm Theory

Tube No.	$\frac{L}{D}$	Actual Collapse lb/in.^{2}	Theoretical Collapse lb/in.^{2}	Difference	Percentage of Theoretical Value
1.1	14	770	860	-90	-10.45
2.1	"	720	830	-110	-13.25
3.1	"	800	900	-100	-11.1
1.2	4	1340	1550	-210	-13.55
2.2	"	1330	1560	-260	-16.7
3.2	"	1375	1700	-325	-19.1
1.3	3	1860	2140	-280	-13.1
2.3	"	1660	2150	-480	-22.8
3.3	"	2070	2350	-280	-11.9
1.5	2	2440	2420	+20	+0.83
2.5	"	2400	2450	-50	-2.04
3.5	"	2340	2540	-150	-5.9
1.6	1.5	2675	2630	+45	+1.71
2.6	"	2600	2640	-40	+1.52
3.6	"	2890	2750	+140	+5.1
1.8	1.0	3075	2900	+175	+6.05
2.8	"	2900	2900	Nil	Nil
3.8	"	3100	2950	+150	+5.08
1.9	0.8	3140	3050	+90	+2.95
2.9	"	2950	3050	-100	-3.28
3.9	"	3175	3110	+65	+2.09

TABLE XIV

Results of Tests on 1" Dia × 24 S.W.G. × T58 Steel Tubes compared with Collapse Pressures Predicted by Sturm Theory

Tube No.	$\frac{L}{D}$	Actual Collapse lb/in.^{2}	Theoretical Collapse lb/in.^{2}	Difference	Percentage of Theoretical Value
1.1	14	1040	1030	+10	+0.97
2.1	"	1075	1010	+65	+6.44
3.1	"	1000	1100	-100	-9.1
1.2	4	1720	1720	Nil	Nil
2.2	"	1875	1720	+155	+9
3.2	"	1625	1820	-195	-10.7
1.3	3	2780	2700	+80	+2.96
2.3	"	2775	2800	-25	-0.89
3.3	"	2750	2880	-130	-4.51
1.5	2.0	3520	3200	+320	+10
2.5	"	3730	3250	+480	+14.8
3.5	"	3450	3330	+120	+3.6
1.6	1.5	4530	3850	+680	+17.7
2.6	"	4600	4000	+600	+15
3.6	"	4475	3960	+515	+13
1.8	1.0	5400	4500	+900	+20
2.8	"	5650	4600	+1050	+22.8
3.8	"	5575	4700	+875	+18.6

TABLE XV

Results of Tests on 1" Dia x 24 S.W.G. Commercial Brass Tubing compared with Collapse Pressures Predicted by Sturm Theory

Tube No.	L/D	Actual Specimen Collapse	Theoretical Collapse	Difference	Percentage of Theoretical Value
1.1	14	335	303	+30	+9.9
2.1	"	415	410	+5	+1.22
3.1	"	375	330	+45	+13.6
1.2	4.8	500	470	+30	+6.4
2.2	"	595	540	+55	+10.2
3.2	"	540	520	+20	+3.86
1.3	3.8	725	690	+35	+5.07
2.3	"	870	750	+120	+16
3.3	"	800	750	+50	+6.67
1.4	2.8	1125	930	+195	+21
2.4	"	1230	1060	+170	+16
3.4	"	1160	1060	+100	+9.45
1.5	1.8	1525	1250	+275	+22
2.5	"	1680	1380	+300	+21.8
3.5	"	1650	1380	+270	+19.6
1.6	1.3	2060	1550	+510	+32.9
2.6	"	2100	1750	+350	+20
3.6	"	2200	1750	+450	+25.7
1.7	1.0	2450	1800	+650	+36
2.7	"	2580	1950	+630	+32.3
3.7	"	2520	1940	+580	+29.9
1.8	0.8	2780	2060	+620	+30.1
2.8	"	2850	2250	+600	+26.7
3.8	"	2820	2200	+620	+28.2
1.9	0.6	3200	2400	+800	+33.3
2.9	"	3230	3600	+630	+17.5
3.9	"	3120	2530	+590	+23.3
1.10	0.4	3750	2900	+850	+29.3
2.10	"	3800	3100	+700	+22.6
3.10	"	3680	3000	+680	+22.7

TABLE XVI

Results of Tests on 1" Dia x 24 S.W.G. x D.T.D. 460 Light Alloy Tubes compared with Collapse Pressures Predicted by Sturm Theory

Tube No.	L/D	Specimen No.	Actual Collapse lb/in.^{2}	Theoretical Collapse lb/in.^{2}	Difference	Percentage of Theoretical Value
1.1	14	B	280	275	+5	+1.82
2.1	"	B	286	280	+6	+2.14
3.1	"	A	280	273	+7	+2.56
1.3	4	B	518	520	-2	-0.38
2.3	"	B	560	520	+40	+7.7
3.3	"	A	490	510	-20	-3.42
1.4	3	B	850	840	+10	+1.19
2.4	"	B	778	850	-72	-8.47
3.4	"	A	760	820	-60	-7.32
1.5	2	B	1020	1020	Nil	Nil
2.5	"	B	1050	1075	-25	-1.43
3.5	"	A	990	1030	-40	-3.88
1.6	1.5	B	1620	1530	+90	+5.88
2.6	"	B	1580	1510	+70	+4.64
3.6	"	A	1410	1410	Nil	Nil
1.8	1.0	B	1890	1880	+10	+0.53
2.8	"	B	1870	1880	-10	-0.53
3.8	"	A	1980	1790	+190	+10.6
1.9	0.8	B	2080	2060	+20	+0.98
2.9	"	B	2190	2060	+130	+6.31
3.9	"	A	2150	1990	+160	+8.04

TABLE XVII

Mean Collapse Pressures and Standard Deviations of Experimental Results expressed as Percentage of and Percentage Variations from Collapse Pressures Predicted by Sturm Theory respectively

Tube size and specification	Mean Pressure	Standard Deviation
2¼" diameter × 24 S.W.G. × T45	98.08%	6.16%
1¾" " × 22 S.W.G. × T45	98.6%	8.66%
1" " × 24 S.W.G. × T45	105.3%	6.49%
1" " × 22 S.W.G. × T45	102.74%	4.58%
1" " × 20 S.W.G. × T45	101.8%	4.96%
1" " × 17 S.W.G. × T45	92.25%	3.2%
1" " × 24 S.W.G. × D.T.D. 305	77.8%	7.44%
1" " × 24 S.W.G. × T55	102.78%	12.5%
1" " × 24 S.W.G. × T26	100.07%	8.64%
1" " × 24 S.W.G. × T58	106.96%	9.86%
1" " × 24 S.W.G. × D.T.D. 102A	94.28%	8.74%
1" " × 24 S.W.G. × Brass	119.8%	9.56%
1" " × 24 S.W.G. × D.T.D. 460	100.66%	4.84%

TABLE XVIII

Values of Stress Coefficient ψ and Non-Dimensional Coefficient ξ as Functions of $\frac{t}{D}$ and $\frac{e}{t}$

β → / α		00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.10	0.11	0.12
0.01	ψ	50.51	51.00	51.50	52.02	52.55	53.08	53.63	54.19	54.76	55.35	55.95	56.56	57.18
	ξ	1.0097	1.02	1.03	1.04	1.051	1.0617	1.0726	1.0838	1.0952	1.107	1.119	1.1312	1.1436
0.02	ψ	25.51	25.75	26.00	26.25	26.51	26.77	27.04	27.31	27.59	27.88	28.17	28.47	28.78
	ξ	1.0204	1.03	1.04	1.05	1.0604	1.0708	1.0808	1.0924	1.1036	1.1152	1.1268	1.1388	1.1512
0.03	ψ	17.18	17.34	17.50	17.67	17.83	18.00	18.18	18.36	18.54	18.73	18.92	19.11	19.31
	ξ	1.0308	1.0404	1.05	1.0602	1.0698	1.08	1.0908	1.1016	1.1124	1.1238	1.1352	1.1466	1.1586
0.04	ψ	13.02	13.14	13.25	13.37	13.50	13.62	13.75	13.88	14.02	14.15	14.29	14.44	14.58
	ξ	1.0416	1.0512	1.06	1.0696	1.08	1.0896	1.1	1.1104	1.1216	1.132	1.1432	1.1552	1.1664
0.05	ψ	10.53	10.61	10.71	10.80	10.90	11.00	11.10	11.20	11.30	11.41	11.52	11.63	11.74
	ξ	1.053	1.061	1.071	1.08	1.09	1.1	1.11	1.12	1.13	1.141	1.152	1.163	1.174
0.06	ψ	8.865	8.938	9.013	9.089	9.167	9.247	9.327	9.411	9.495	9.582	9.670	9.761	9.854
	ξ	1.0638	1.0726	1.0816	1.0907	1.1	1.1096	1.1192	1.1293	1.1394	1.1498	1.1604	1.1713	1.1825
0.07	ψ	7.680	7.741	7.804	7.867	7.932	7.998	8.066	8.135	8.206	8.278	8.352	8.427	8.505
	ξ	1.075	1.083	1.092	1.101	1.1105	1.1197	1.1293	1.1389	1.149	1.159	1.169	1.1798	1.191
0.08	ψ	6.793	6.845	6.898	6.952	7.007	7.064	7.121	7.180	7.240	7.301	7.364	7.428	7.494
	ξ	1.0869	1.0953	1.1035	1.1122	1.121	1.13	1.139	1.1487	1.1585	1.168	1.178	1.188	1.1989
0.09	ψ	6.105	6.150	6.195	6.242	6.289	6.338	6.387	6.438	6.490	6.543	6.597	6.652	6.709
	ξ	1.0988	1.107	1.115	1.1236	1.132	1.141	1.1498	1.1588	1.168	1.1779	1.187	1.197	1.2075
0.10	ψ	5.556	5.595	5.634	5.675	5.716	5.758	5.802	5.846	5.891	5.937	5.984	6.033	6.082
	ξ	1.1112	1.1190	1.1268	1.135	1.1432	1.1516	1.1604	1.1692	1.1782	1.1874	1.1968	1.2066	1.2164

$$\psi = \frac{2[1 + (1-2\alpha)^2 - 4\alpha\beta(1-2\alpha) - 4\alpha^2\beta^2]}{[(1-2\alpha)^2 + 1]\,[1 - (1-2\alpha)^2 - 4\alpha\beta(1-2\alpha) - 4\alpha^2\beta^2]} \; ; \quad \alpha = \frac{t}{D} \; ; \quad \beta = \frac{e}{t}$$

TABLE XIX

Mean Collapse Pressures and Standard Deviations of Experimental Results corrected for Eccentricity of Bore, expressed as Percentage of and Percentage Variations from Collapse Pressures Predicted by Sturm Theory respectively

Tube size and specification	Mean Pressure	Standard Deviation
$2\frac{1}{4}$" diameter × 24 S.W.G. × T45	98.3%	6.4%
$1\frac{3}{4}$" " × 22 S.W.G. × T45	100.6%	6.56%
1" " × 24 S.W.G. T45	105.5%	6.58%
1" " × 22 S.W.G. T45	102.95%	4.44%
1" " × 20 S.W.G. × T45	102.4%	4.84%
1" " × 17 S.W.G. × T45	104.7%	7.12%
1" " × 24 S.W.G. × D.T.D. 305	81.90%	7.6%
1" " × 24 S.W.G. T55	102.8%	12.5%
1" " × 24 S.W.G. T26	100.1%	8.6%
1" " × 24 S.W.G. × T58	107%	9.9%
1" " × 24 S.W.G. × D.T.D. 102A	98.9%	11.1%
1" " × 24 S.W.G. Brass	119.8%	9.6%
1" " × 24 S.W.G. D.T.D. 460	100.7%	4.8%

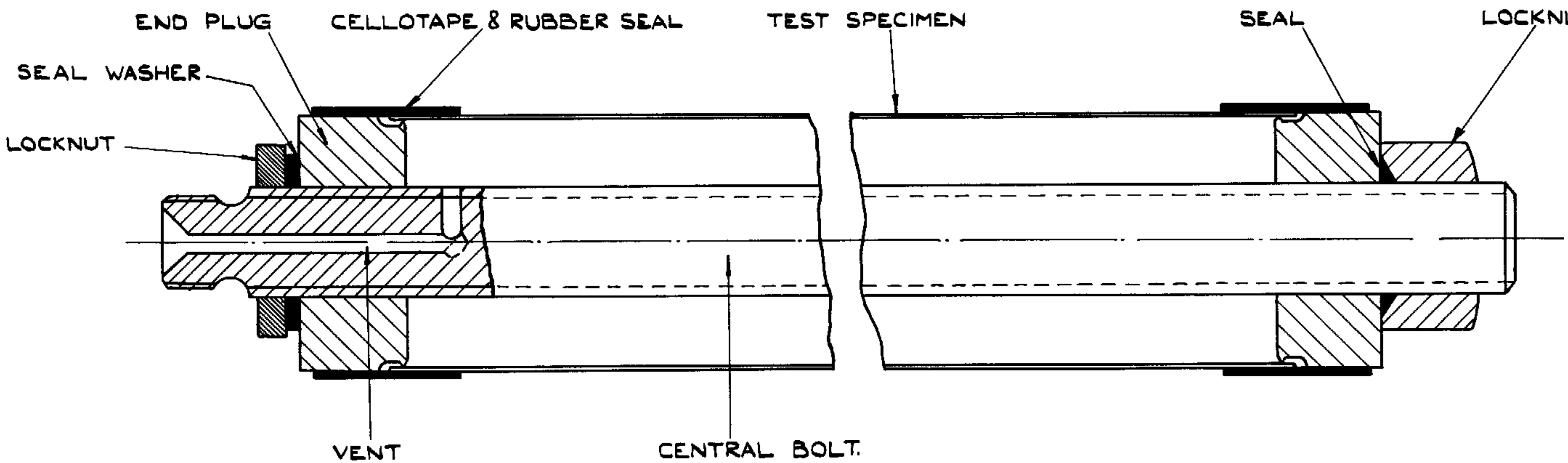


FIG. 1. DIAGRAM OF THE TEST RIG FOR $2\frac{1}{4}''$ DIAMETER AND $1\frac{3}{4}''$ DIAMETER SPECIMEN.

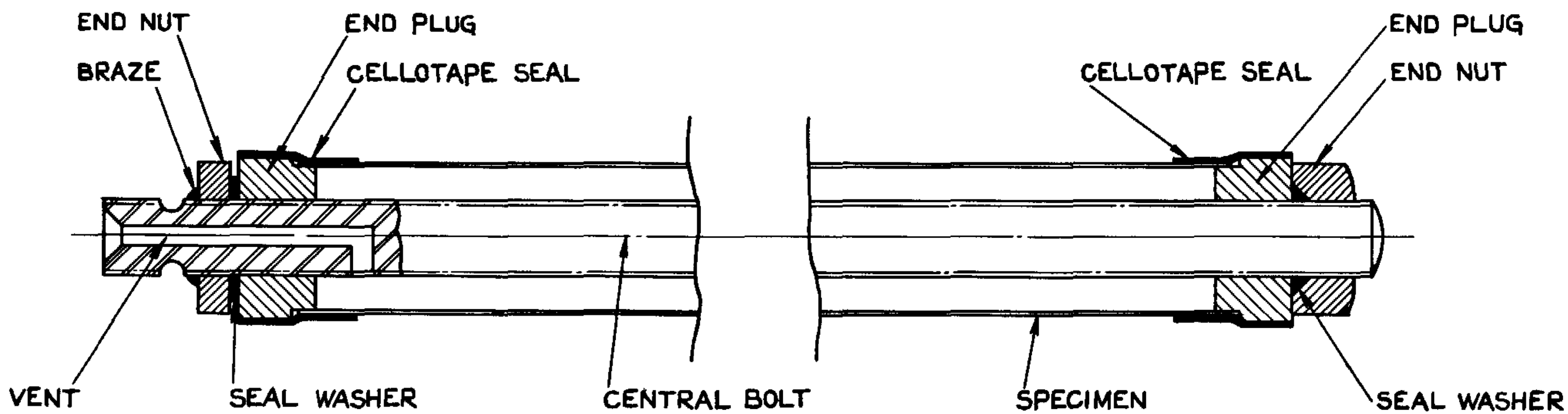


FIG. 2. DIAGRAM OF TEST RIG FOR 1" DIA. SPECIMENS.

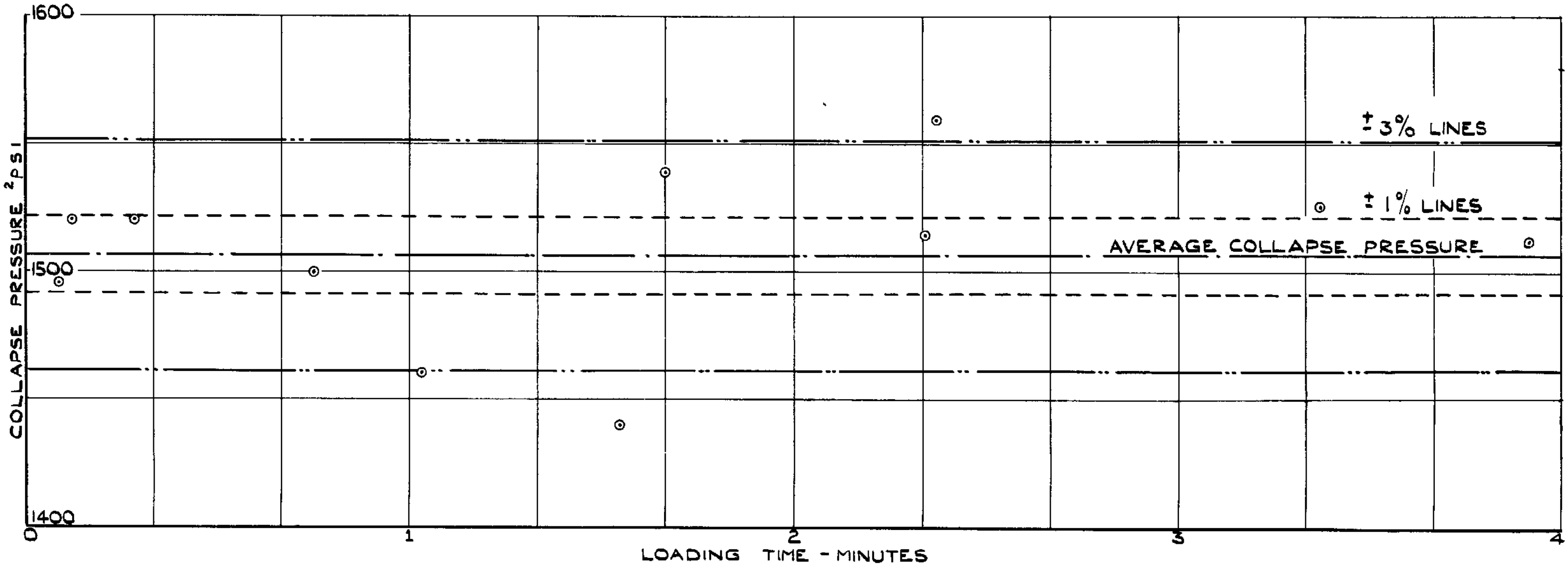


FIG. 3. THE COLLAPSE PRESSURE OF 1¾" O/D × 22 S.W.G. T45 STEEL TUBE AS A FUNCTION OF RATE OF LOADING.

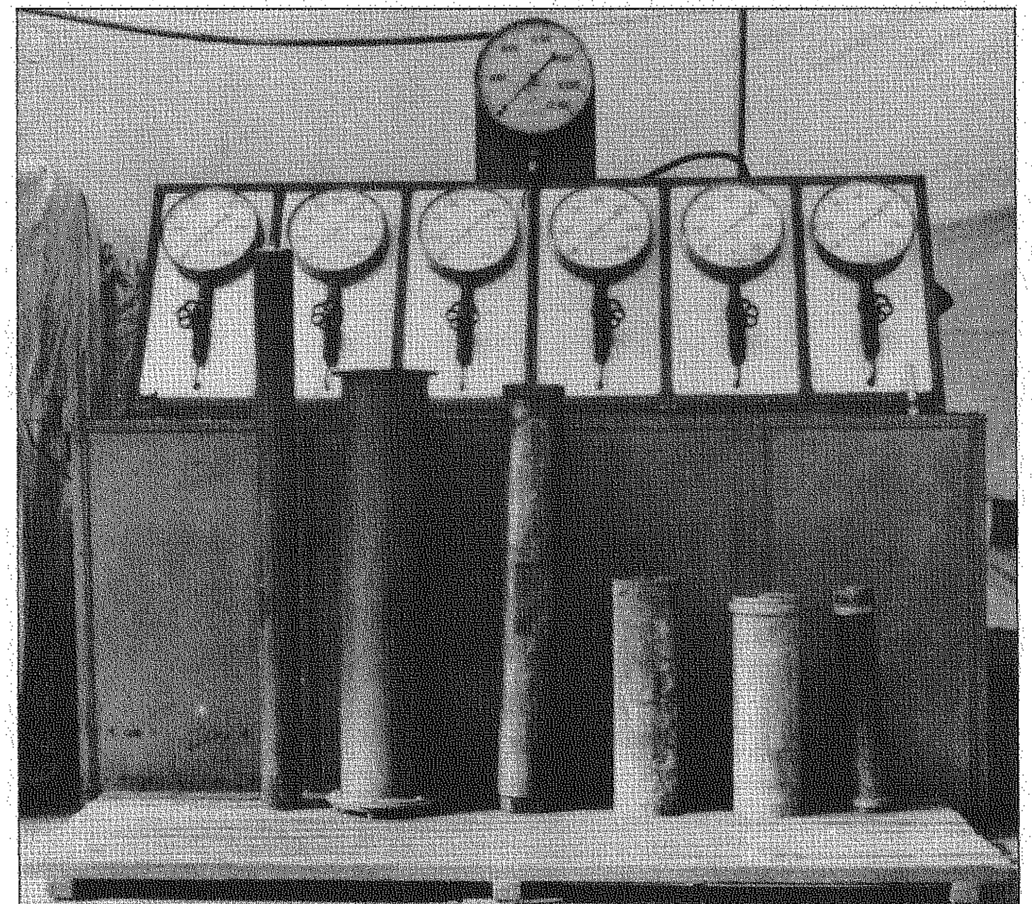


FIG.4. GENERAL VIEW OF TEST INSTALLATION

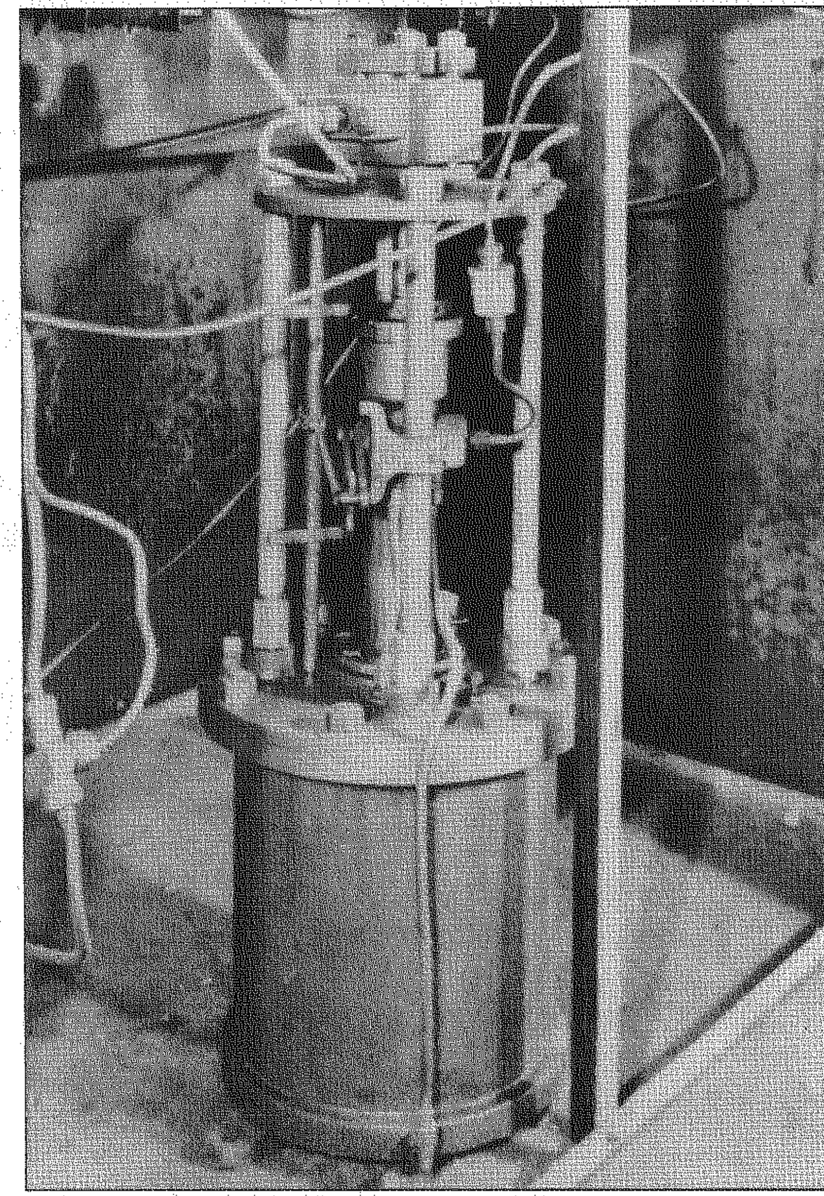
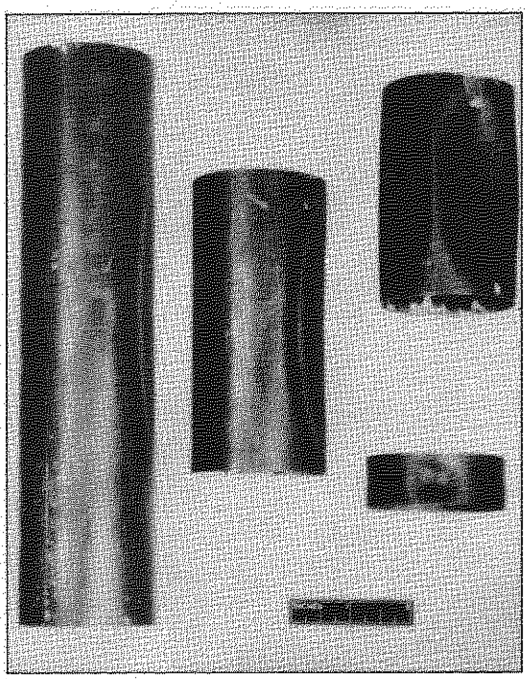
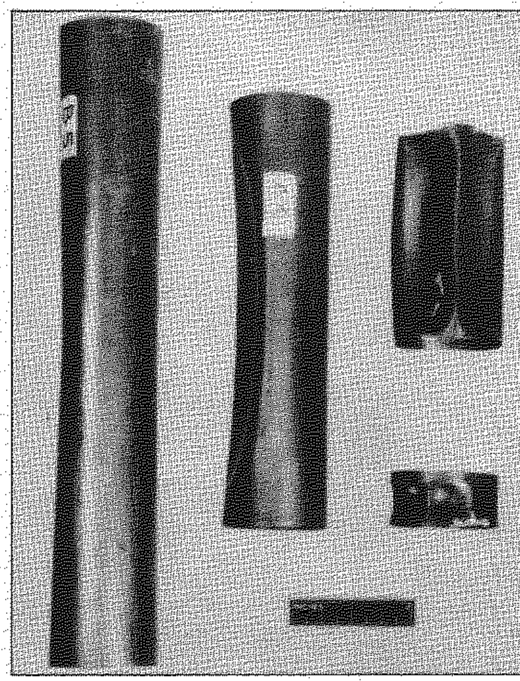
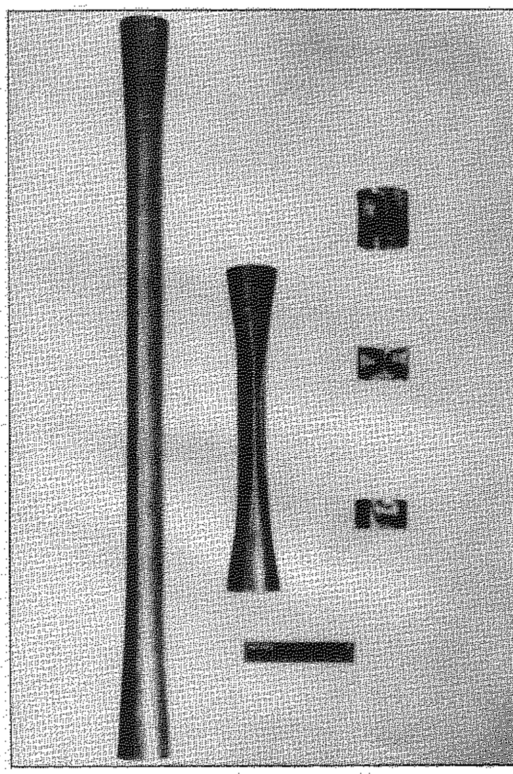
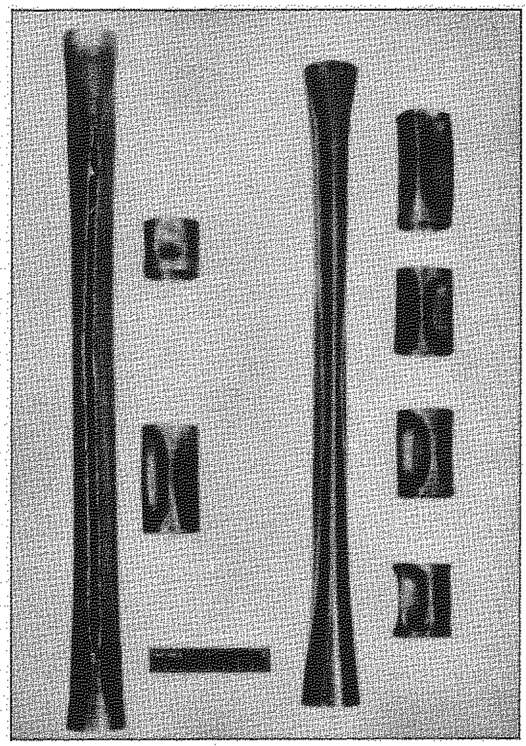


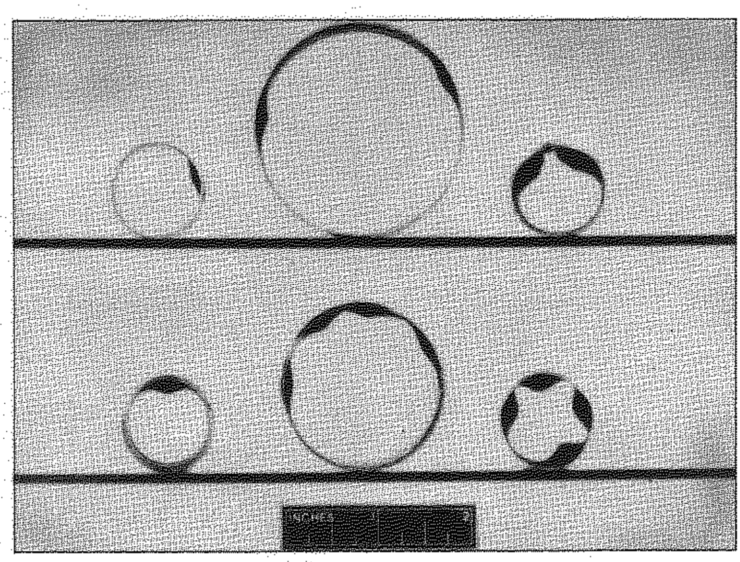
FIG.5. HYDRAULIC RAM










INCHES

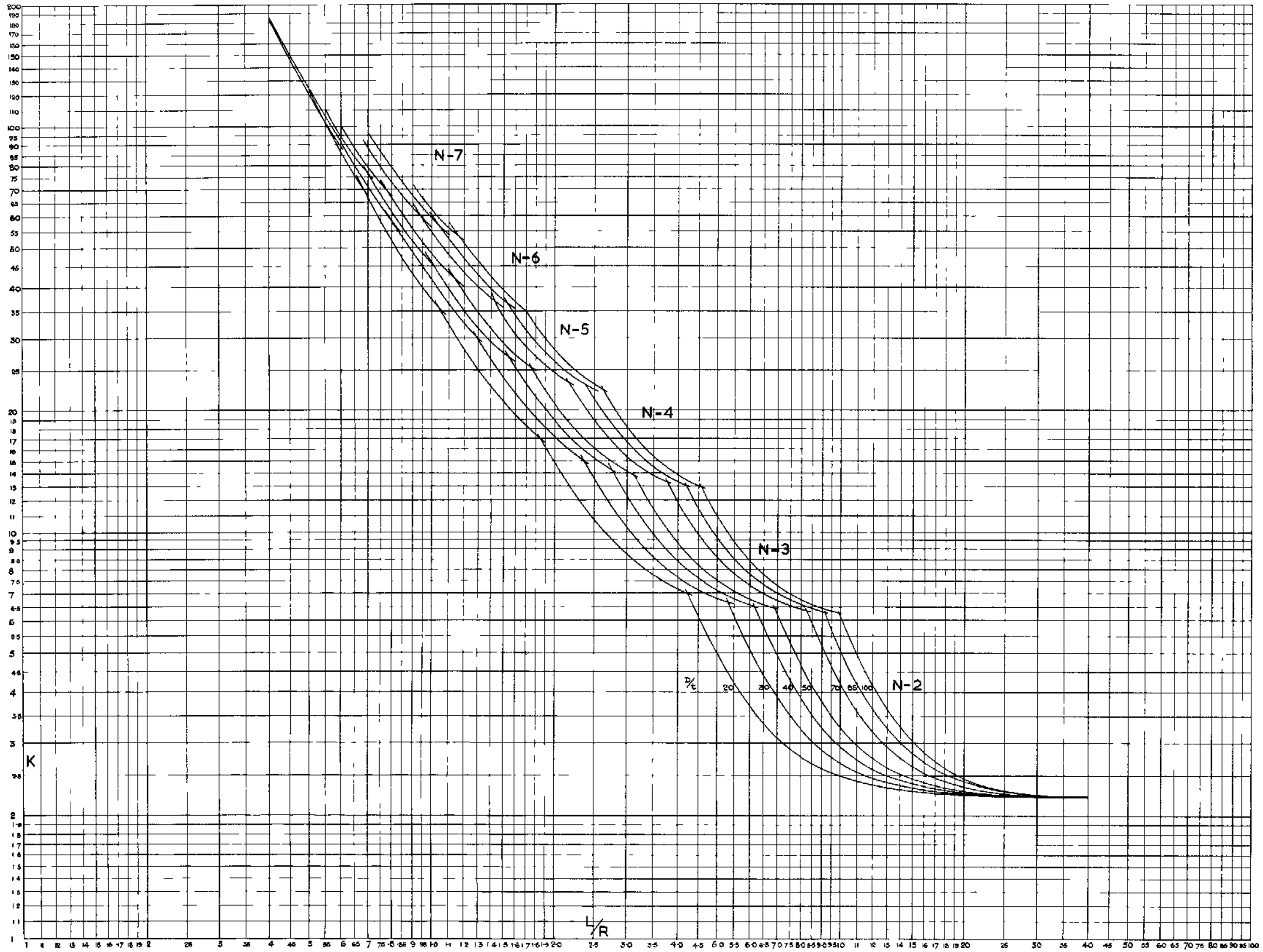


FIG 7 COLLAPSE COEFFICIENTS FOR ROUND CYLINDERS WITH PRESSURE ON THE SIDES ONLY EDGES SIMPLY SUPPORTED FROM — UNIVERSITY OF ILLINOIS BULLETIN Nº 12 NOV 1941 — 'A STUDY OF THE COLLAPSE PRESSURE OF THIN WALLED CYLINDERS' BY R G STURM

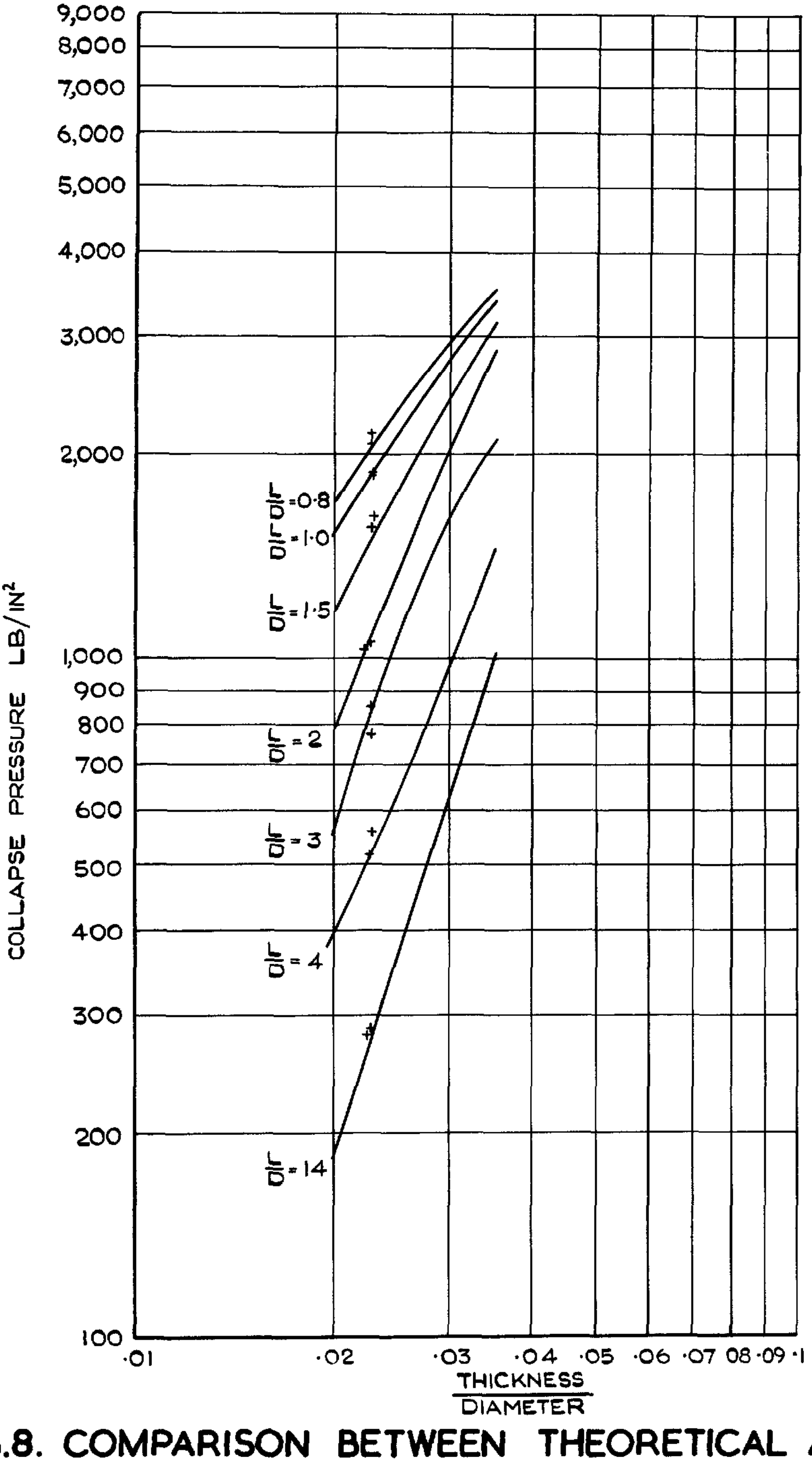


FIG.8. COMPARISON BETWEEN THEORETICAL AND EXPERIMENTAL COLLAPSE PRESSURES FOR LIGHT ALLOY TUBES TO SPECIFICATION D.T.D. 460.

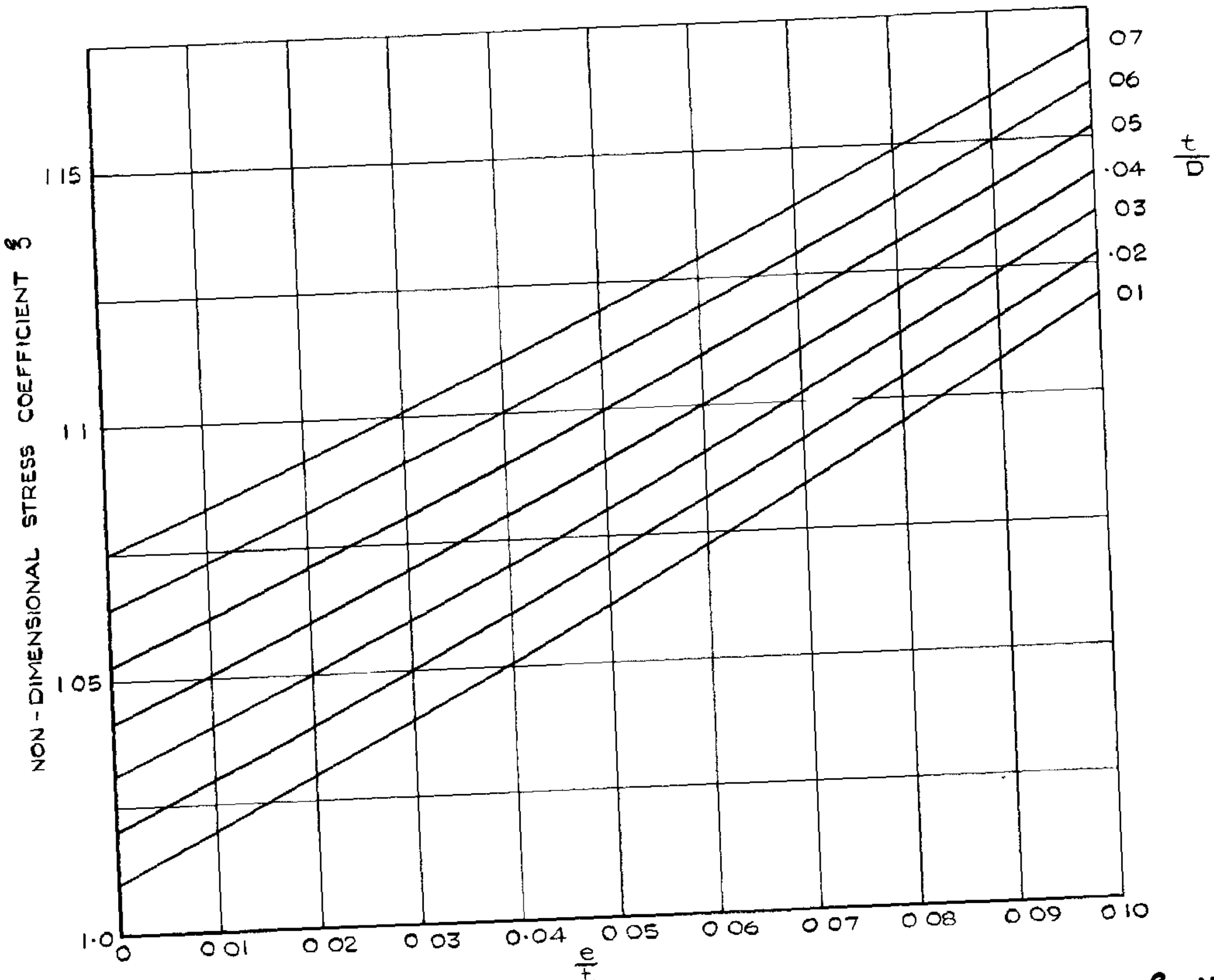


FIG. 9. VARIATION OF NON-DIMENSIONAL STRESS COEFFICIENT ξ WITH e/t FOR GIVEN VALUES OF t/D.

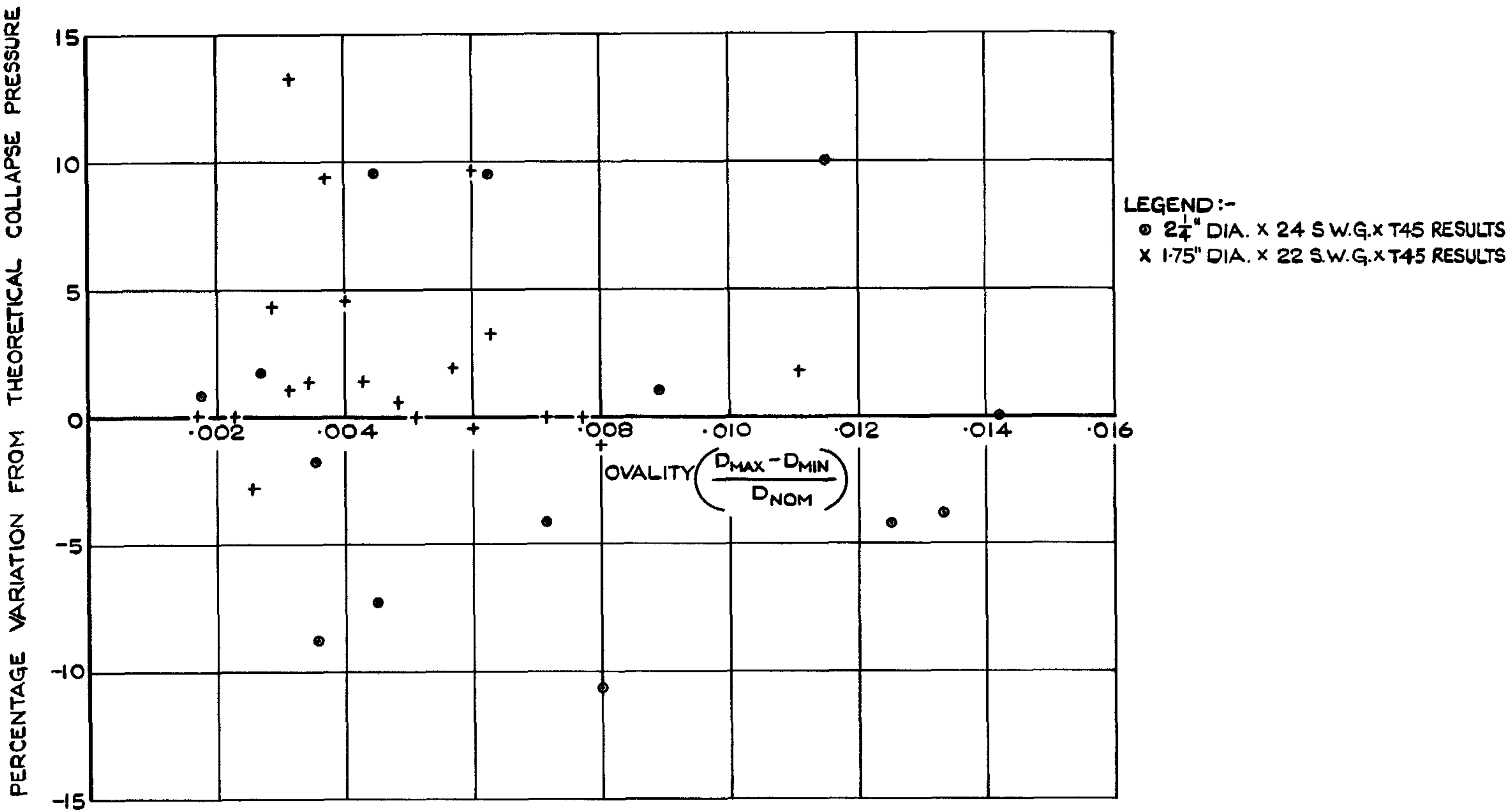


FIG. 10. THE EFFECT OF OVALITY ON COLLAPSE PRESSURE FOR $2\frac{1}{4}$ X 24 S.W.G. AND $1\frac{3}{4}$ X 22 S.W.G. × T45 STEEL TUBES.

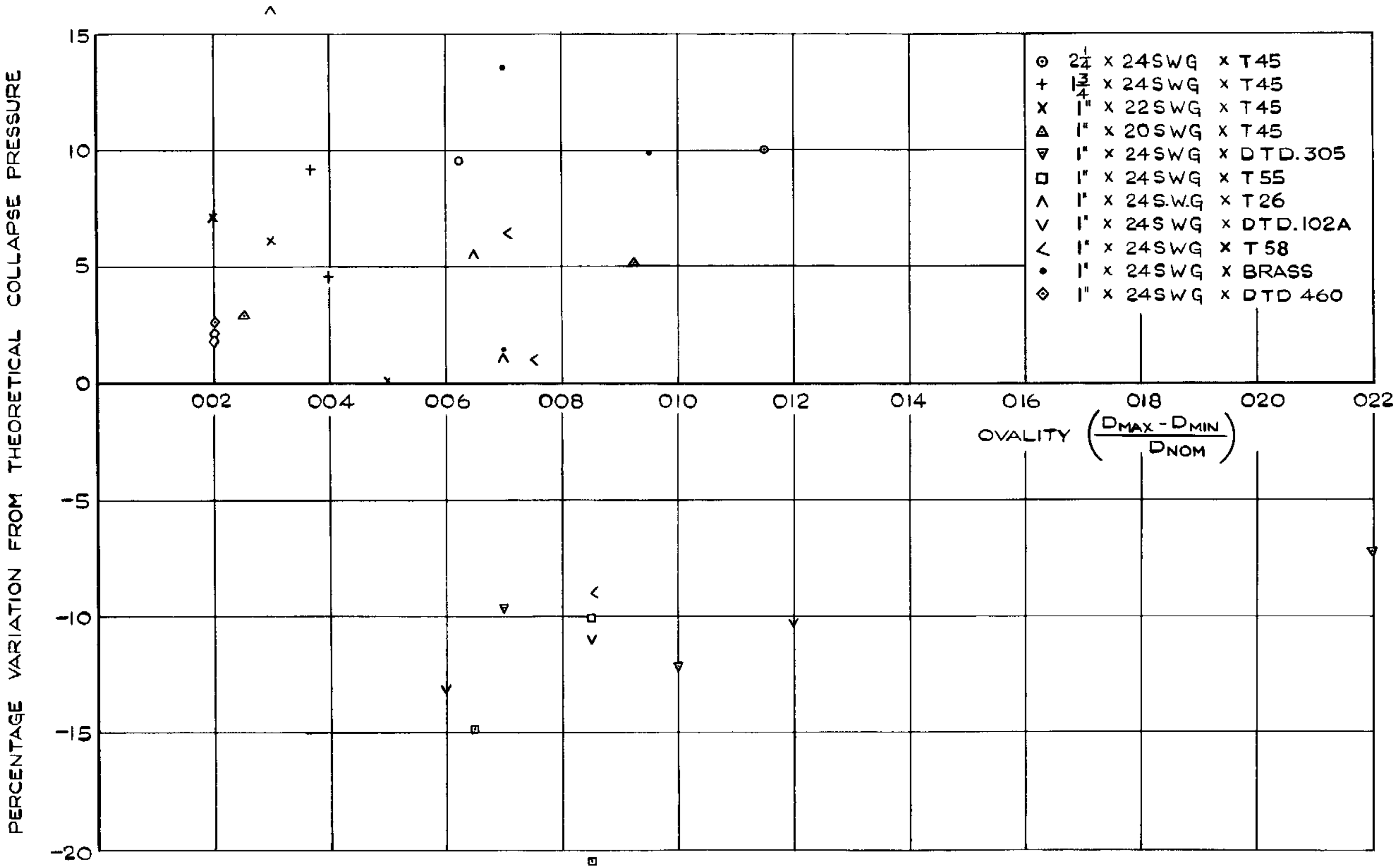


FIG.11. THE INFLUENCE OF OVALITY ON THE COLLAPSE PRESSURE OF LONG TUBES.

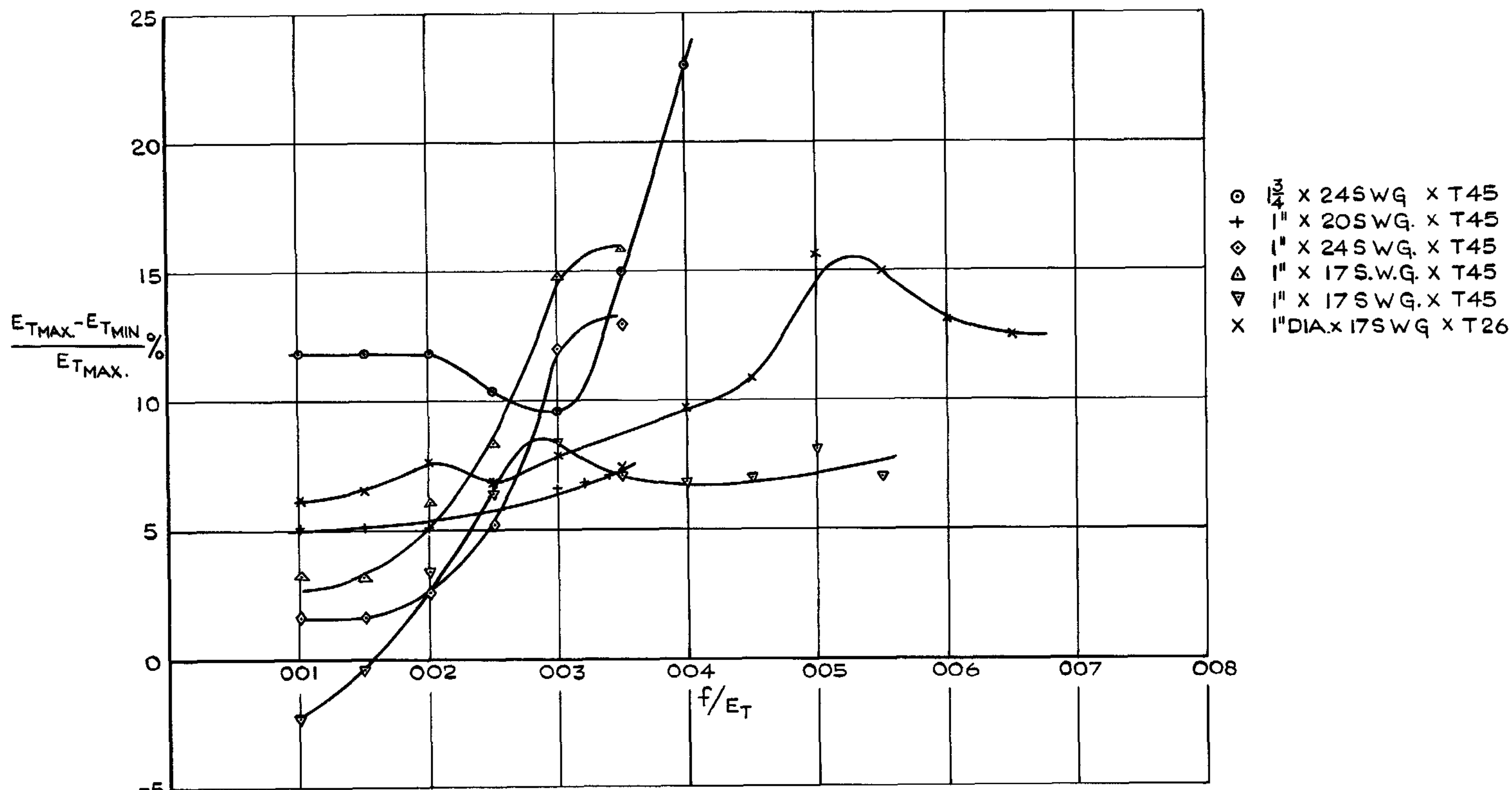
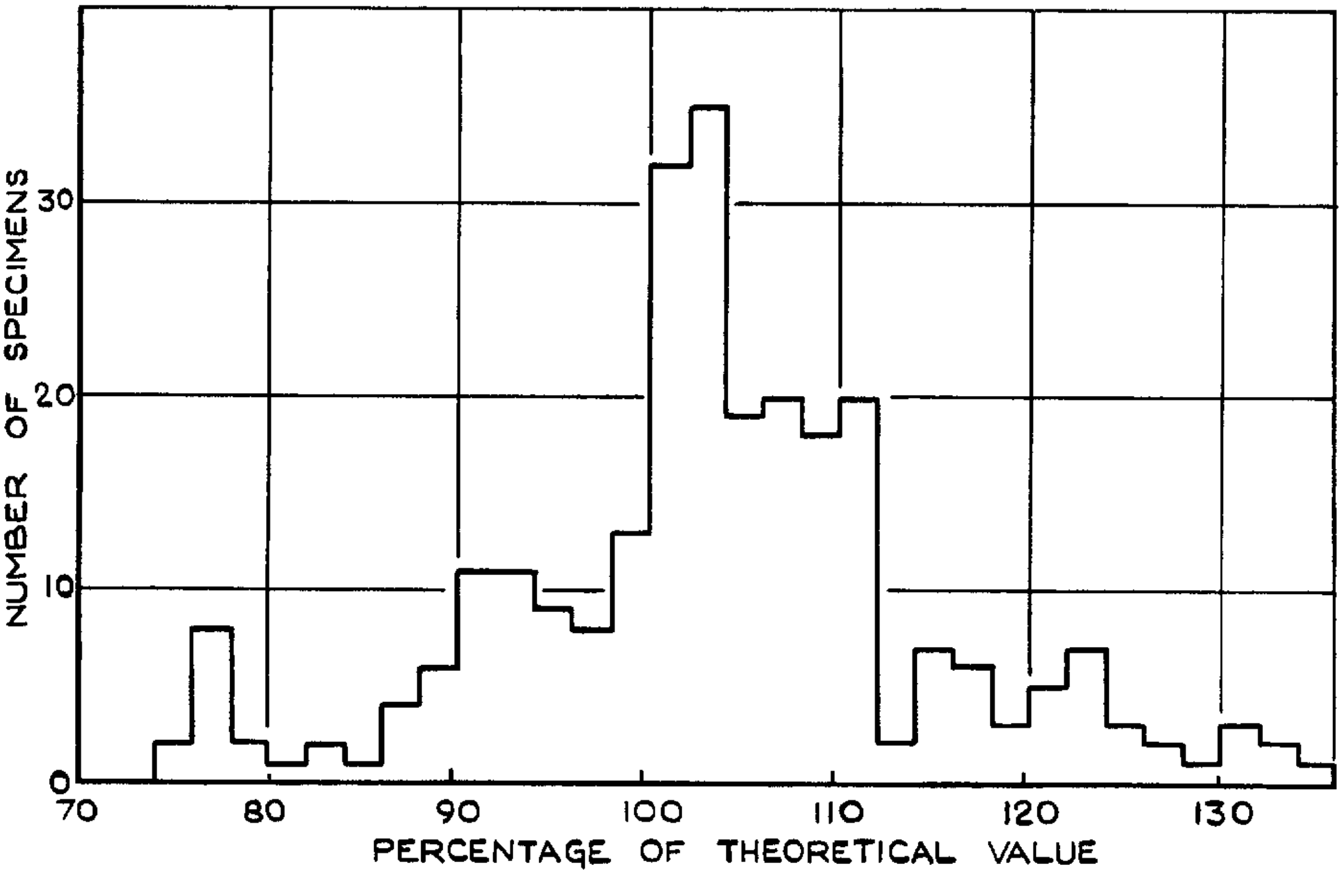
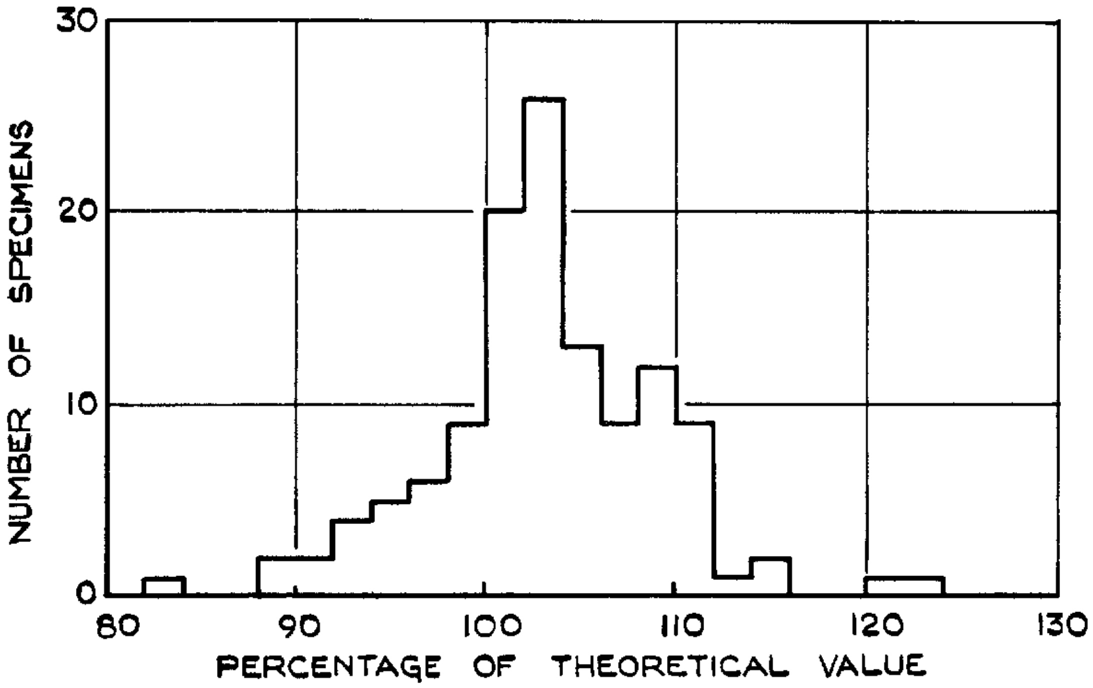


FIG. 12. PERCENTAGE VARIATION OF TANGENT MODULUS AS A FUNCTION OF f/E_T FOR VARIOUS TUBES.



(a) COMPLETE SERIES OF TESTS.



(b) PRIMARY PHASE RESULTS ONLY.

FIG. 13 (a & b). DISTRIBUTION OF EXPERIMENTAL RESULTS AS A FUNCTION OF PERCENTAGE VARIATION FROM VALUE PREDICTED BY STURM THEORY.

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