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Abstract

Fatigue design in offshore structures is based on S-N curves derived from tests on tubular joints where failure is defined as penetration of wall thickness. However, in practice, fatigue cracks are likely to continue to grow around the weld circumference after breaking through the wall and it has been found in certain circumstances that a significant residual life remained after through-thickness cracking.

The purpose of this thesis is to analyse and compare data to see if exists any correlation with different factors or parameters from different tubular joints and their residual life. This data of tubular joints was collected from several reports that have been done through years by different organizations and laboratories in which distinct testing conditions have been taken into account with the purpose to simulate the joints to be offshore. Some examples of the different parameters taking into considerations by these organizations and laboratories are e.g. type of joints, loading conditions, loading spectrums, environment, welding profile.

To analyse the data several evaluations of statistics were performed and with help of statistical software named "Statgraphics" different plots like probability distributions were realized in order to see which is the best fit for the data gathered, but not only plots were made there. Also, some regression analyses were executed for assessing if there exists any major influence or correlation between the different factors and the residual life.

Some basic designs of S-N curves and S-N curves with modified thickness as given on "DNVGL-RP-C203" [1] for the stages of failure of N1 and N3 were plotted and compared to the S-N curves in the "OTH 92 390" [2] report. For last, a comparison of the conclusions from the report of "Zhang and Wintle" [3] to the results of the data gathered was conducted.

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Symbols and abbreviations

Table 1 Symbols and abbreviations

Symbol	Description
AX	Axial Loading
CA	Constant amplitude
CEL	Compressive chord end member
COV	Covariance
CP	Cathodic protection
D	Diameter of chord
d	Diameter of brace
D	Durbin Watson test
df	Degree of freedom
DNV	Det Norske Veritas
e_i	Residual
exp	Exponential
FC	Free Corrosion
HSS	Hot Spot Stress
IPB	In-plane-bending
k	Thickness exponent
L	Least square method
ln	Natural logarithm
log	Logarithm
MAE	Mean of the absolute error
MS_E	Mean square error
N	Number of cycles
N1 – N4	Stages of progression of crack during fatigue testing
NK	Non overlapping K joint
OK	Overlapping K joint
OPB	Out-of-plane bending
PWHT	Post weld heat treatment
Q_g	Gap factor
Qu	Strength factor
Q_β	Geometrical factor
R	Stress ratio
r	Correlation coefficient
R^2	Coefficient of determination R-squared

R^2_{adj}	Coefficient of determination adjusted R-squared
Re	Residual life through thickness crack
SCF	Stress concentration factor
SD	Standard deviation
S-N	Cycle stress vs number of cycles
sqrt	Square root
SS_E	Sum of squares error
SSR	Regression sum of squares
Std dev	Standard deviation
t	Thickness through of a chord member which a crack will most likely grow
T	Chord wall thickness
t	Brace wall thickness
t_{ref}	Reference thickness
VA	Variable amplitude
β	Brace to chord diameter ratio (D/d)
β_0	Point in which the straight-line intercept or crosses the axis
β_1	Slope of the line in which increase of decreases the Y variable
γ	Chord thinness ratio [(D/2)/T]
ε	Random error with zero mean and variance
τ	Brace to chord wall thickness ratio (t/T)
$\bar{a}$	Intercept of design S-N curve with log N axis
$\hat{\sigma}$	Standard error of estimation
$\Delta\sigma$	Stress range

Acknowledgement

This thesis is my final work in which I conclude a 2-year program master's degree in Mechanical and Structural Engineering and Material Science with specialization in Offshore Structures at the University of Stavanger in Stavanger, Norway. The work for this thesis was carried out from February 2021 to June 2021.

I wish to express my deep gratitude for the support and help offered through this 2-year path of my master's degree to my family in Mexico, which even at a long distance they were always there supporting.

Also, to my thesis supervisors, Gerhard Ersdal and Mostaffa Ahmed Atteya for all their immense support and guidance thought this master thesis work in which they have been really helpful and understandable with all their positive attitude giving me great advice, feedback, and having extraordinary good talks during this work which has been very complicated and challenging due to the pandemic situation which we are going through these moments.

Sincerely,

Alejandro Alvarez Kubicki

1. Introduction

1.1. Background

Fatigue it's an important parameter that is taken into consideration when designing offshore structures. As for the fixed steel structures offshore, tubular joints are submitted to cyclic loadings and forces e.g. wind, waves. Which causes fatigue damage and compromises the service life of the structure. For decades has been a cooperative effort of the industry to research the affection caused to tubular joints.

These investigations had led to many evaluations with the purpose to understand clearly and to find if there exists any correlation between the affectations occurring to the different types of tubular joints and the distinct parameters which are taken into account that may reduce the life service of them.

From results obtain on experiments performed in the laboratories, S-N curves have been designed for the different stages of fatigue presented on the tubular joints and with the purpose for a better understanding of the behaviour of the element, to realize how much stress can be submitted before reaching their fatigue limit and with this estimate how long it will be the service life of the element before it needed to be repaired or changed, thus avoiding any major accident in the structure which the element or elements will be.

1.2. Objective

From a compilation of different laboratories and reports published, create a database of more than 400 tubular joints which is will be used to perform statistical assessments of the effects of different testing conditions and geometrical parameters on the remaining fatigue life beyond crack initiation.

Those statistical assessments include:

- Plot the data to different probability distribution and see which one fit best.
- Design S-N curves for the different stages of failure with the hot spot stress and the modified effect of thickness correction.
- Assess residual life through-thickness crack (Re), (N1/N3), and (N3-N1)/N3 with different factors and parameters to see if there exists any correlation with them and show the best fit model of each of them.
- Plot the S-N curves with the same parameters as the ones in the "OTH 92 390" [2] then compare these with the ones in the report.
- Compare the conclusions from "Review and assessment of the fatigue data from Zhang and Wintle" [3] with the data collected to see if there is any difference.

2. Theory

2.1. Fatigue of Tubular Joints

2.1.1. Introduction

Fatigue is the process of a progressive and localized permanent structural alteration, which is produced in a material subjected to cyclic loading and deformations at some point or points and that may culminate in cracks or complete fractures after a sufficient number of fluctuations.

The principal factors that affect the fatigue life are:

- The stress ranges.
- The number of cycles
- The environment component is placed in.
- The geometry of the tubular members of the structure.

Fatigue of welded components is a phenomenon that is not possible to describe by physical theories, and as a result, the design requirements are based on empirical formulae based on test data. The design S-N curves in standards are based on laboratory experiments of specimens subjected to cyclic stress of a certain form and amplitude and the number of cycles to failure is determined.

The results of the fatigue tests are normally presented as plots of stress range versus the number of cycles to failure in a logarithmic scale. As these are significant uncertainties related to the fatigue life of a component, these plots will show a statistical dispersion of these fatigue data.

The two most common methods for representing the stress are:

- Nominal stress range, where the member stress is used in the calculation of the fatigue life (stress undisturbed by the joint and weld). This requires an S-N curve specific to the detail type in question.

- Hot spot stress (HSS), whew the geometric stress at the weld toe is used in the fatigue life calculations, omitting the effect of the local weld stress. This stress incorporates the effect of the overall geometry but omits the stress concentrating influences on the weld to itself which results in local stress distribution. Hence it is considerably lower than the peak stress nut provides a consistent stress level for use with the fatigue design S-N curve.

S-N curves for tubular joints, the subject of this thesis, are utilizing the hot spot stress (HSS) approach. The HSS can be determined by the nominal stress amplified by a stress concentration factor (SCF), based on joint geometry and load pattern. These SCF can be determined by several methods, including parametric equations (see e.g. Efthymiou 1988) and finite element analysis. SCFs are in experimental methods and finite element analysis defined as the greatest value around the brace/chord intersection of the linear extrapolation to the weld toe of the geometric stress distribution near the weld toe. [4]

The stages of failure are explicitly stated as four types of N-values which are:

N1 The first sign of cracking was given by 15% strain change measured in the miniature strain gauge nearest the crack. [4]

N2 Intermediate surface cracking as detected by visual examination and if the crack length is 30 mm or more this stage is considered to have been reached. [2]

N3 First crack through the plate thickness of the damaged member. [4]

N4 End of test, extensive through-thickness cracking leading to loss of specimen stiffness or asymmetrical loading or limitation of the actuator stroke or unacceptable side load on the actuator bearings. For out-of-plane bending specimens, N4 was deemed to have been reached when a crack in the chord of length 1.5 times the brace diameter was observed. [4]

The N3 value is normally used to define the S-N curve, As will be shown later in this thesis, when plotting the data of HSS versus N3 cycles, a scatter will show. S-N curves are established by statistical evaluations of this scatter of data, typically by the mean value of the S-N curve and a design S-N curve sufficiently to the safe side (e.g. mean value minus two standard deviations). Examples of establishing design S-N curves based on the available database in shown in Section 0

2.1.2. S-N Curve

The S-N curves mentioned above are the main methods to assess fatigue analysis of the life structures under cyclic loading [5].

The basic design S-N curve is given by [1]:

$$\log N = \log \bar{a} - m \log \Delta\sigma \qquad (1)$$

Where:

N	=	predicted number of cycles to failure for stress range $\Delta\sigma$
$\log \bar{a}$	=	intercept of log N-axis by S-N curve
m	=	negative inverse slope of S-N curve
$\Delta\sigma$	=	stress range with unit Mpa

The modified S-N curve for thickness effect is given by [1]:

$$\log N = \log \bar{a} - m \log \left(\Delta\sigma \left(\frac{t}{t_{ref}} \right)^k \right) \qquad (2)$$

Where:

N	=	predicted number of cycles to failure for stress range $\Delta\sigma$
$\log \bar{a}$	=	intercept of log N-axis by S-N curve
m	=	negative inverse slope of S-N curve
$\Delta\sigma$	=	stress range with unit Mpa
t	=	thickness through which a crack will most likely grow

t_{ref}	=	reference thickness for tubular joints is equal to 16 mm
k	=	thickness exponent on fatigue strength is 0.10 for tubular butt welds made from one side

The experimental test indicates a change in the slope of the S-N curves in some situations (in air and seawater with cathodic protection), as shown in Figure 1.

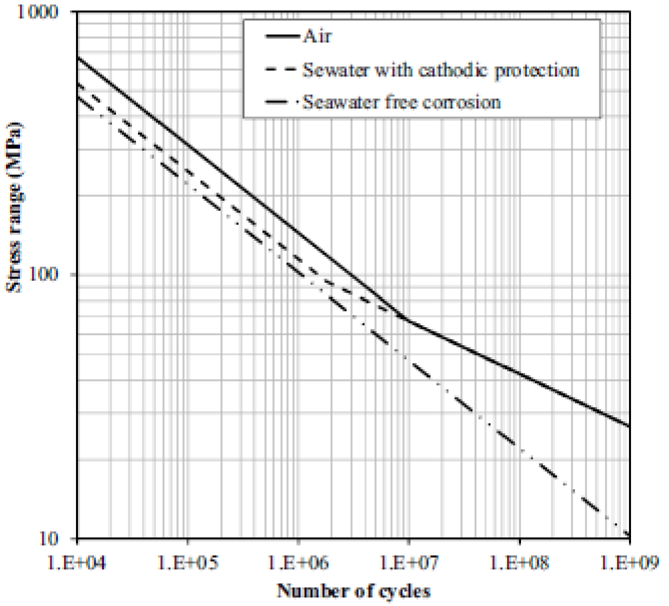


Figure 1 S-N curves for tubular joints [1]

The parameters for the S-N curves shown in Figure 1 are given in Table 2.

Table 2 S-N curves for tubular joints [1]

Environment	m_1	$\log \overline{a}_1$	m_2	$\log \overline{a}_2$	*Fatigue limit at 10^7 cycles (MPa)*)*	*Thickness exponent k*
Air	$N \leq 10^7$ cycles		$N > 10^7$ cycles			
	3.0	12.48	5.0	16.13	67.09	0.25
Seawater with cathodic protection	$N \leq 1.8 \cdot 10^6$ cycles		$N > 1.8 \cdot 10^6$ cycles			
	3.0	12.18	5.0	16.13	67.09	0.25
Seawater free corrosion	3.0	12.03	3.0	12.03	0	0.25

2.1.3. Factors influencing fatigue

Fatigue is seen to be influenced by some factors or characteristics of the different tubular joints; here are some of them that have been considered to produce an effect on them.

2.1.3.1. Type of Joint

According to [6] the joints classification is subdivided into three basic planar types which are: Y, K, and X joints. This classification is based solely on the process whereby the axial force is on the brace.

From the three basic joints just mentioned many more exist from combinations of those, containing mixtures in one plane or several planes e.g. T-joints is a Y-joint which angle between the brace and chord is 90º.

In some cases, overlapping exist in joints this is when the braces overlap in-plane or out-of-plane at the chord member. Simple Y and X joints have no overlap, but simple K joints have some overlaps in their principal braces.

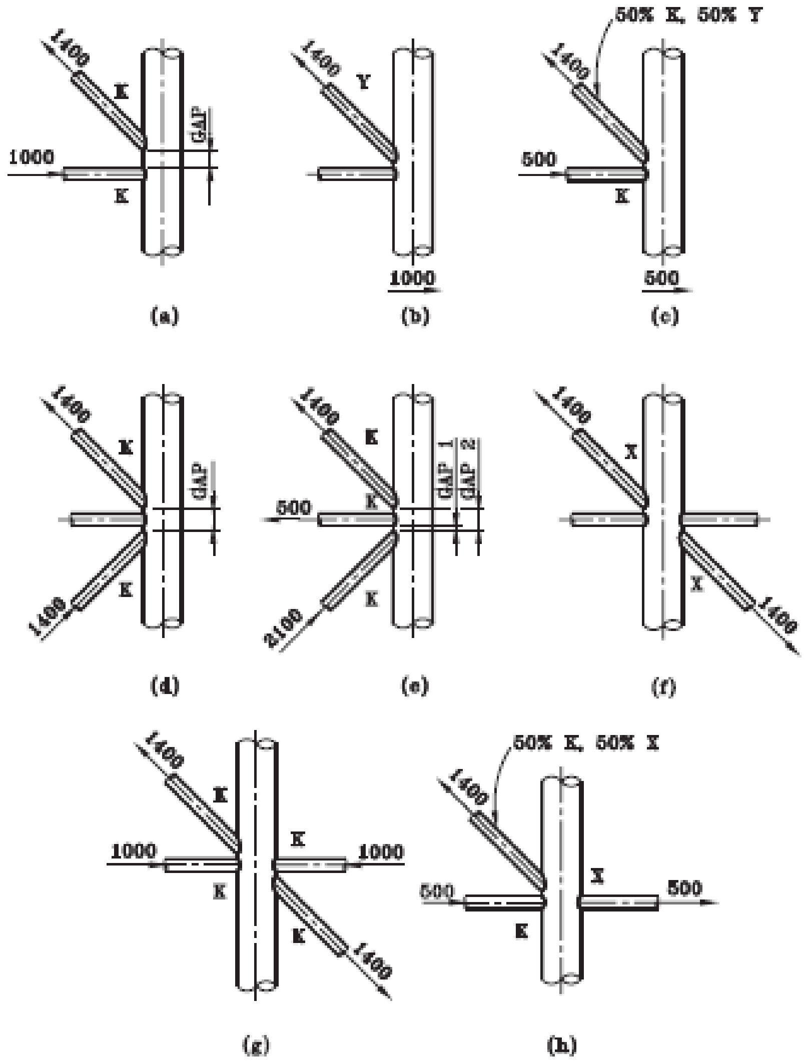


Figure 2 Classification of simple joints [7]

2.1.3.2. Weld Profile

As for the welding profile, limited investigations have shown there is no clear evidence that weld profiling leads to improved fatigue performance [6]. For the study of the thesis, the weld profiles were classified into three main types of profiles which are: As welded, Weld improvement, Repaired joints.

- As welded joints contain significant tensile residual stresses induced by the welding process.

- For weld improvement, there are many types of techniques but basically, these techniques improve depending on which one is applied some improve the fatigue performance, stress concentrations, and/or modify residual stress.

- Repaired joints are methods considered when tubular joints present cracks and it is necessary to repair the entire joint or only the cracked region e.g. burr grinding, hole grinding. [5]

2.1.3.3. Joint Geometry

The geometry of the joints variated, and this makes that some geometrical parameters also. According to the dimensions from the recompilation of the data the joint geometry dimensions are going from 139.8 mm to 2000 mm at Chord OD and their chord wall thickness from 3.89 mm to 78 mm, meanwhile the dimensions for the Brace OD are from 60.6 mm to 915 mm and the Brace wall thickness from 3 mm to 43.9 m.

In the figures below can be seen different types of tubular joints and their geometrical definitions.

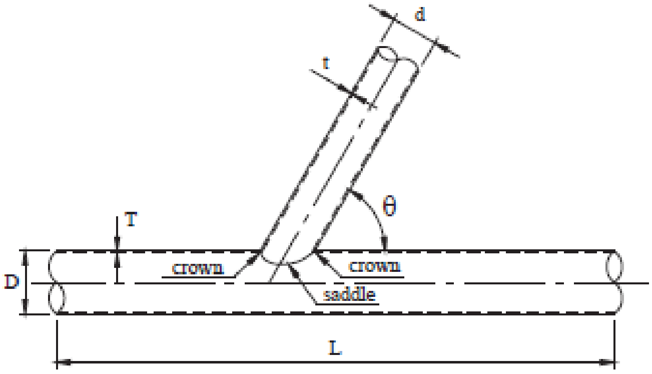


Figure 3 Geometrical parameters for T- or Y- joints [7]

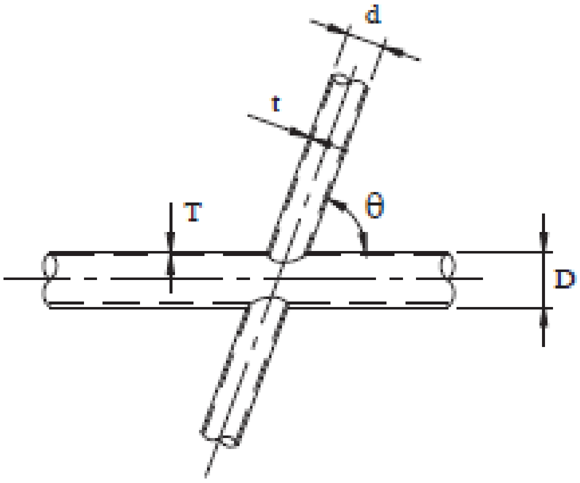


Figure 4 Geometrical parameters for X-joints [7]

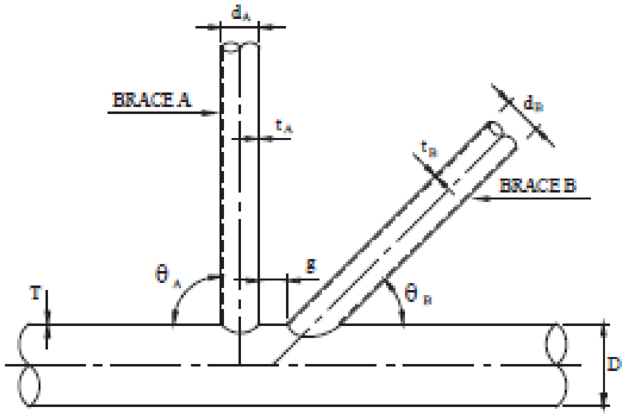


Figure 5 Geometrical parameters for K-joints [7]

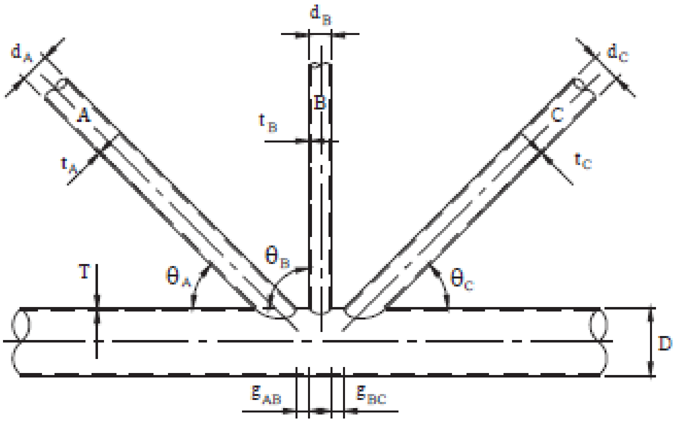


Figure 6 Geometrical parameters for KT-joints [7]

Once its Chord and Brace dimensions are known, we can calculate some geometrical parameters such as β, τ, γ.

$$\beta = \frac{d}{D} \tag{3}$$

$$\tau = \frac{t}{T} \tag{4}$$

$$\gamma = \frac{D}{2T} \tag{5}$$

2.1.3.4. Environment

Different environments to which the samples were exposed during the tests was to recreate a structural joint in offshore installation and these types of conditions are:

- In Air.
- Seawater free corrosion: To represent a joint simply immersed in seawater. [4]
- Seawater with Cathodic Protection: To reproduce the common practical case of an offshore structure that is cathodic protected to prevent the large scale of general corrosion. [4]

2.1.3.5. Loading Spectrum

The majority of the specimens tested in different laboratories were subjected to constant amplitude loads. However, specimens subjected to a variable amplitude have also been carried out using various narrow band load spectra [4], but these are not included in the work in this thesis.

2.1.3.6. Loading Type

There different loading types to which the joints were subjected are Axial loading, In-plane bending, and Out-of-plane bending. In some of the different loadings just mentioned there was also a compressive loading added with the end to simulate the dead weight loading from an offshore platform. The abbreviations used for the loading cases in the thesis can be seen in Table 3

Table 3 Loading cases abbreviations

AX	Axial loading
IPB	In-plane-bending
OPB	Out-of-plane bending
CEL	Compressive chord end-member

2.2. Modelling of uncertainty by probabilistic distribution

For engineering decisions analysis is subjected to uncertainties, where the uncertainties should be interpreted and differentiated regarding their type and origin. In this way it has become standard to differentiate between uncertainties like the ones due to inherent natural variability, which is considered an aleatory uncertainty or type 1, meanwhile, model's uncertainties and statistical uncertainties are referred to as epistemic uncertainties or type 2. In principle, all prevailing types of uncertainties should be considered in engineering decision analysis within the framework of Bayesian probability theory. [8]

2.2.1. Random Variables

Basic random variables are defined in [8] as the parameters that represent the available knowledge as well as the associated uncertainty in the considered model. These random variables must represent all types of uncertainties that are included in the analysis and for this the uncertainties considered are:

- Physical uncertainties are typically associated with loading environments, the geometry of structures, material properties, and repair qualities.

- Statistical uncertainties arise due to incomplete statistical information.

2.2.2. Selection of a probabilistic model

From [9] the selection of a probabilistic model sometimes is based only on empirical decisions but a useful technique to decide which probabilistic mode use is to plot data in a probability paper, for this a sufficient amount of data need to be available such that also find and include some data from the tail region, where most are where our main interest lie.

After gathering the data and plotted in a probability paper need to estimate parameters for the selected distributions, in this case, can be used in the method of moments o to fit the estimated parameters in a straight line to the empirical distribution on the paper.

Then the selected distribution must be tested because the limited amount of data involves uncertainties related to the choice of type of distribution or the estimation of parameters.

One thing we need to have in mind always is that we can never prove that a fitted model is the correct one, we can only indicate whether are good reasons to reject or not the model.

2.2.3. Probability plots

As in " [10]" the probability plots are a graphical technique for assessing data set following a given distribution. The data is plotted against the theoretical distribution and, if the data is following this distribution, it should form approximately a straight line.

Probability plots can be generated for several competing distributions to see which distribution provides the best fit. The probability plots which are used in this thesis are normal, lognormal, and Weibull plots.

2.3. Regression Analysis

Regression analysis is a statistical technique that aims to investigates and model in a mathematical form the behaviour of one variable of response in function to one or more independent variables.

With the use of a mathematical model, it's possible to describe the relation, so that model can be used for different purposes of prediction, optimization, and control. This type of analysis is used in different kinds of fields like engineering, economics, sciences, etc.

As in [11] "the regression models are frequently used to analyse data from unplanned experiments, that might arise from observations of uncontrolled phenomena or historical records".

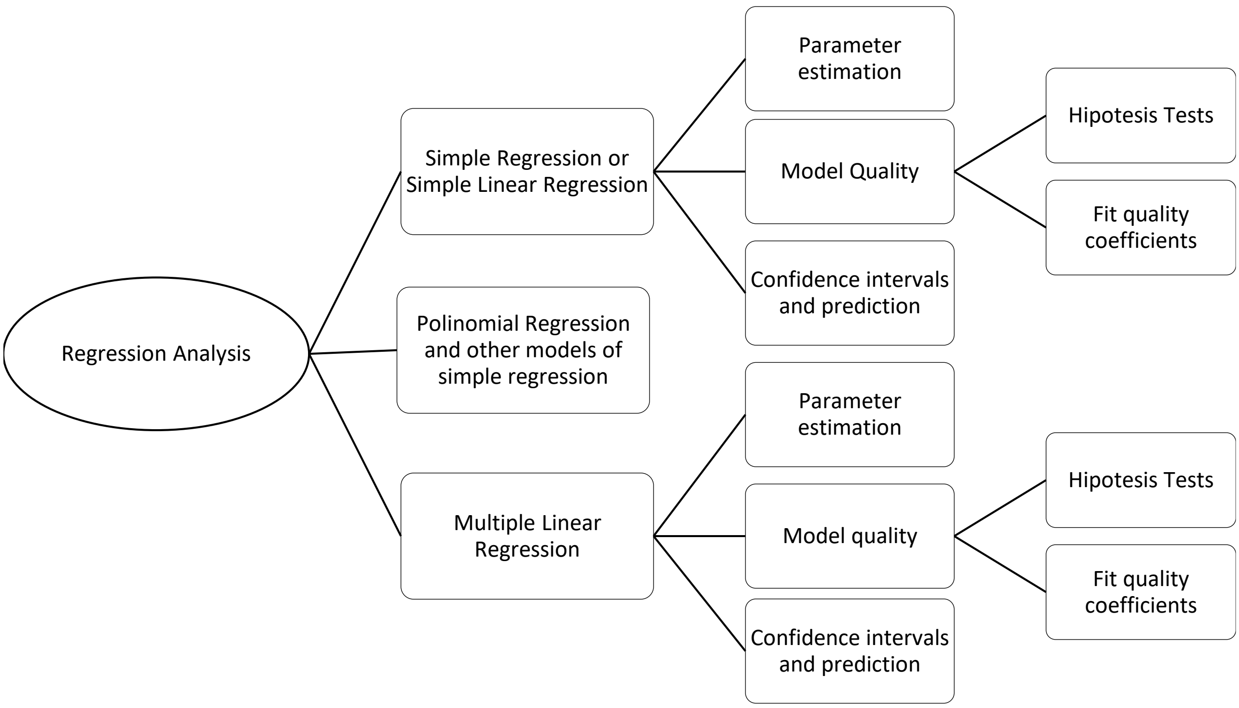


Figure 7 Conceptual map for regression analysis

2.3.1. Simple Regression

It's a procedure designed to describe the impact of a factor on a dependant variable constructing a statistical model, when the variables are X and Y, Y is considered the dependent variable o response variable meanwhile X is the independent variable o regressor variable.

A regression model able to study the behaviour of Y with respect to X can be adjusted to a mathematical model in the shape of:

$$Y = f(X) \tag{6}$$

Assuming the variables X and Y are linearly related and for every value of X, the Y value is a random variable or dependent. Then the observation for Y can be described by the model:

$$Y = \beta_0 + \beta_1 X + \varepsilon \tag{7}$$

Also known as a simple linear regression model in which β_0, β_1 are model parameters that are constants that its necessary to estimate.

Where:

- ε is a random error with zero mean and variance σ^2
- β_0 is the point at which the straight-line intercepts or crosses the axis.
- β_1 is the slope of the line.

2.3.2. Multiple Regression

It's a procedure designed to describe the impact of two or more factors on a dependant variable constructing a statistical model, the same as in the simple regression the variables are X and Y, Y for the dependant variable meanwhile X for the independent variables.

For this analysis, a fitted model is used to predict and include confidence limits. Assuming is a polynomial of the first order the mathematical model can be:

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + \varepsilon \tag{8}$$

Interpretation of the parameters of the multiple regression equation is the same as the ones in the simple regression.

2.3.3. Estimation of parameters

To fit the data obtained into a model for the different regression analysis there are some coefficients or parameters that can be estimated, these methods for estimating the parameters or model fittings are from [11], [12], [13] included their functions to calculate them, this is the following:

The least-square method is a procedure to estimate parameters of a regression model in order to minimize the errors of the fit to the model. The least-square method can be obtained by the function:

$$L = \sum_{i=1}^{n} (\varepsilon_i)^2 = \sum_{i=0}^{n} (y_i - [\beta_0 + \beta_1 x_i])^2 \quad (9)$$

Residuals are the difference between the observed and estimated which serve to analyze the error of the fit to the model, this estimation of the error o residual can be obtained by:

$$e_i = y_i - \hat{y}_i \quad (10)$$

The Sum of squares error is the sum of the squared residuals and it's used to estimate the variance of the fit error to the model this is given by the following function:

$$SS_E = \sum_{i=1}^{n} e_1^2 = \sum_{i=1}^{n} (y_i - \hat{y}_i)^2 = \sum_{i=1}^{n} \left(y_i - [\hat{\beta}_0 + \hat{\beta}_i x_i]\right)^2 \quad (11)$$

Standard error of estimation estimates de standard deviation of the error and indicates a magnitude of the error to the fit model, this is given by:

$$\hat{\sigma} = \sqrt{\frac{SS_E}{n-p}} = MS_E \quad (12)$$

Coefficient of determination R-Squared is a criterion to evaluate the quality of fit is to observe the way in which the model fits the data, in other words, measuring the proportions of variability in the data (Y) explained by the regression model, the function for this coefficient is:

$$R^2 = \frac{SSR}{SSR + SSE} \quad (13)$$

Coefficient of determination Adjusted R-Squared it's used when there are a lot of terms in a model and R-Squared can be misleading by the increment on every term added to the model, the function for this is:

$$R_{adj}^2 = 100 \left[1 - \left(\frac{n-1}{n-2}\right) \frac{SSE}{SSR + SSE}\right] \% \quad (14)$$

A correlation coefficient is the one that measures the intensity of the linear relation between two variables and its function is:

$$r = \frac{\sum_{i=1}^{n} (x_i - \bar{x})\,(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n} (x_i - \bar{x})^2 \sum_{i=1}^{n} (y_i - \bar{y})^2}} \quad (15)$$

The mean of the absolute error (MAE) is the mean of the absolute value of the residuals that are used to see how much the model fails on average when estimating the variable of response.

$$mae = \frac{\sum_{i=1}^{n} |e_i|}{n} \quad (16)$$

Durbin-Watson test is a diagnostic of the presence of correlation between consecutive residuals which is a possible manifestation of the lack of independence. The function for this is:

$$D = \frac{\sum_{i=2}^{n}(e_i - e_{i-1})^2}{\sum_{i=1}^{n} e_i^2} \qquad (17)$$

3. Statistical evaluation of the databases

3.1. Introduction

Aiming to establish a relation between different parameters on tubular joints with the residual life through-thickness crack, several statistical evaluation methods have been performed on three different databases gathered from different tubular joints which have been tested in different laboratories. These tubular joints are welded, subjected to constant cyclic loadings and different conditions with the purpose to simulate the joints in an offshore structure.

In this chapter, the databases are used to determine:

- S-N curve for early crack (N1).
- S-N curve for trough thickness cracks (N3).
- Fit to a probability distribution the residual life through-thickness crack data.
- Simple and multiple regression analysis on different parameters to observe if they are correlated with Re, N1/N3, and (N3-N1)/N3.
- Plot fittest model for each of the regression analysis.
- Differences or similarities to S-N curves from OTH 92 390.
- Differences of similarities to Zhang and Wintle's conclusions.
- Regression analysis using the strength factor (Qu).

Before showing the points that were determined just earlier, an analysis was carried out which mention where the database was compiled, some classifications from the joints tested, and then a statistical evaluation was done of three parameters of interest.

3.2. Database used in the Analysis

The database used in this thesis for the statistical evaluation is a compilation of information from different reports that in turn was a compiled data from tests on tubular joints that were carried out in different laboratories as indicated in Table 4.

In this case, a total of 445 data was collected from different types of tubular joints tests. The references from which the data were obtained were the following:

Table 4 References for compiled data of tubular joints

Reference	Quantity of tubular joints data
Canadian Researches	7
Damilano 1981	16
Dijkstra 1981	5
EC – technical steel	10
ECSC	10
Gibstein 1981	48
Kurobane 1973	28
NEL	8
Ohtake 1978	4
OTH 89 307	25
TWI	38
UKORSP I	188
UKORSP II	34
OTH 92 390	1
Zhang & Wintle	23

Other analysis of the collected data were the classifications for joints, loading spectrum, environment and loading type that can be seen in the following tables:

Table 5 Joint Classification

Joint Type	Quantity
H - Joint	4
T - Joint	308
X - Joint	16
Y - joint	17
N - Joint	4
NK - Joint	30
NKT - Joint	3
OK - Joint	45
OKT - Joint	4
-	14
Total	**445**

Table 6 Loading Spectrum Applied

Abbreviation	Loading Spectrum	Quantity
CA	Constant amplitude	418
VA	Variable amplitude	27
	Total	**445**

Table 7 Tested Environment

Environment	Air	Seawater free corrosion	Seawater with Cathodic Protection	**Total**
Quantity	411	23	11	**445**

Table 8 Loading type

Loading	Quantity
AX	233
AX/CEL	15
IPB	86
IPB/CEL	7
OPB	79
OPB/CEL	6
-	19
Total	**445**

All the information collected and used as a database can be seen in Appendix 1: Collected test results for database.

3.3. Parameters of interest

A statistical evaluation of some of the geometric parameters (β, τ, γ.) of the joints was performed and shown in Table 9, Table 10, and Table 11. With the purpose to illustrate the features of the statistical analysis from the tables distinct box-and-whisker plots were done for each of these parameters.

From [14] the constructed manner of the box-and-whisker plot is the following:

- The box is drawn from the lower quartile to the upper quartile. This interval covers the middle 50% of the data values, sorted from smallest to largest.
- The vertical line is drawn at the median.
- The plus sign is placed at the location of the mean.
- Whisker is drawn from the edges of the box to the largest and smallest values.

Table 9 Summary statistics for β

Quantity	438
Average	0.586
Median	0.5
Standard Deviation	0.229
Minimum	0.25
Maximum	1
Range	0.75
Lower quartile	0.48
Upper quartile	0.6
Interquartile range	0.12

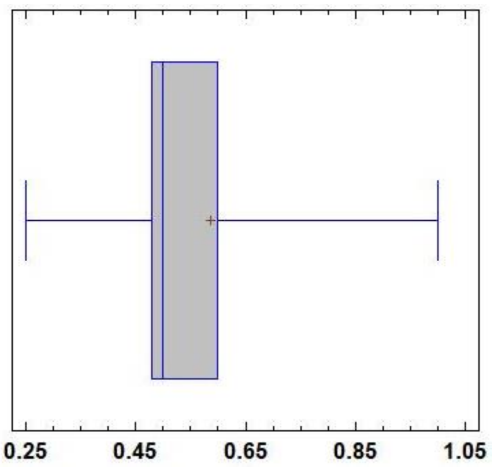


Figure 8 Box-and-Whisker plot for β

Table 10 Summary statistics for τ

Quantity	438
Average	0.681
Median	0.71
Standard Deviation	0.221
Minimum	0.25
Maximum	1
Range	0.75
Lower quartile	0.5
Upper quartile	0.86
Interquartile range	0.36

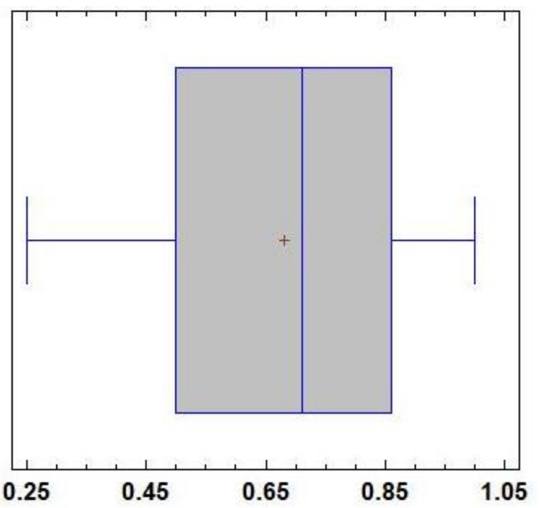


Figure 9 Box-and-Whisker plot for τ

Table 11 Summary statistics for γ

Quantity	445
Average	14.542
Median	14.28
Standard Deviation	5.24
Minimum	8
Maximum	80
Range	72
Lower quartile	13.33
Upper quartile	14.28
Interquartile range	0.95

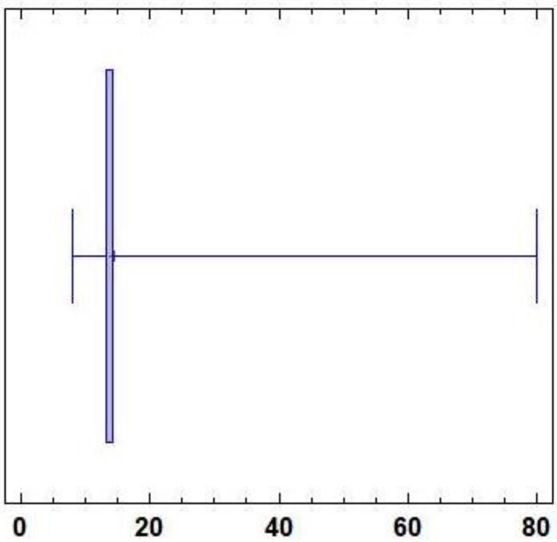


Figure 10 Box-and-Whisker plot for γ

3.4. S-N curves based on the databases

The design S-N curves for specimens tested in air conditions are based on values of N1 and N3 from the full database. From which a total of 228 values for N1 and 318 for N3 was gathered.

To find the log $\bar{a}$ value for the S-N curve the method of the least mean square error was implemented. Once know the log $\bar{a}$ value the standard deviation was calculated and with this the mean – 2SD and mean + 2SD were obtained and later plotted in the S-N curves plots.

Parameters for the S-N curves with values lower or equal to 1e7 are in Table 12 and Table 13.

Table 12 Data for S-N curve when N1 ≤ 1e7 for full database

		HSS	HSS Thickness Corrected
Log a		12.02	12.04
Sum error		3.7E+06	3.7E+06
Std Dev		0.698	0.684
S-N curve Range			
Air	**m**	**Log a**	**Log a**
Design	3	12.48	12.48
Mean - 2*Std dev.	3	10.63	10.67
Mean	3	12.02	12.04
Mean + 2*Std dev.	3	13.42	13.41

The parameters from Table 12 are plotted in Figure 11 and Figure 12.

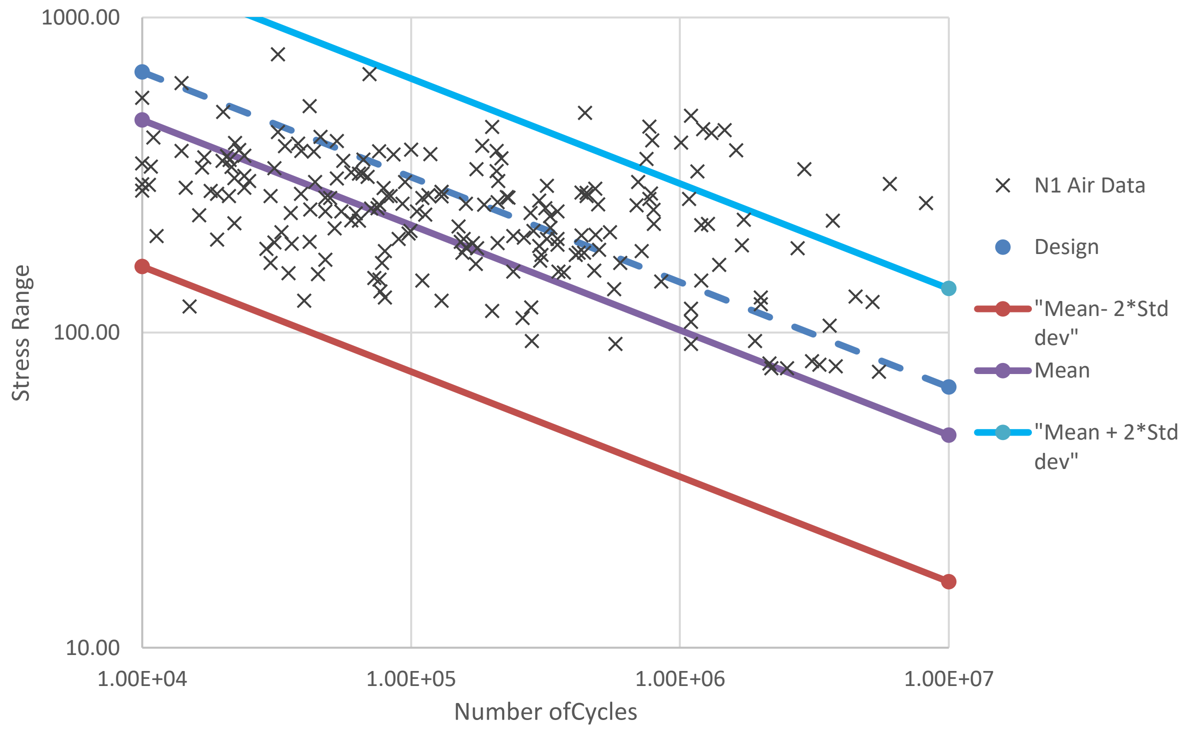


Figure 11 S-N curve for HSS when N1 ≤ 1e7 for full database

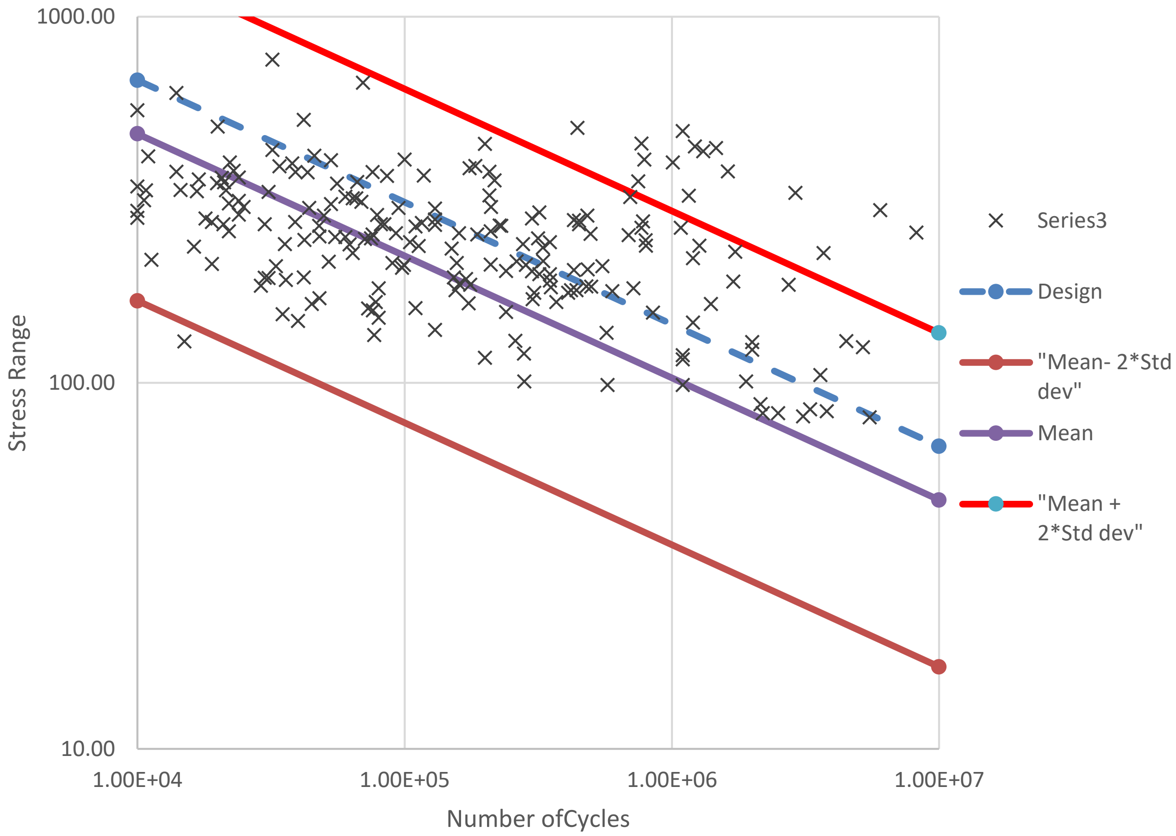


Figure 12 S-N curve for HSS Thickness Corrected when N1 ≤ 1e7 for full database

For the S-N curves from Figure 11 and Figure 12, the data doesn't seem to follow the curves and are all flat at this stage.

Table 13 Data for S-N curve when N3 ≤ 1e7

		HSS	HSS Thickness Corrected
Log a		12.90	12.92
Sum error		3.1E+06	3.01E+06
Std Dev		0.592	0.577
S-N curve Range			
Air	**m**	**Log a**	**Log a**
Design	3	12.48	12.48
Mean - 2*Std dev.	3	11.71	11.77
Mean	3	12.90	12.92
Mean + 2*Std dev.	3	14.08	14.08

The parameters from Table 13 are plotted in Figure 13 and Figure 14.

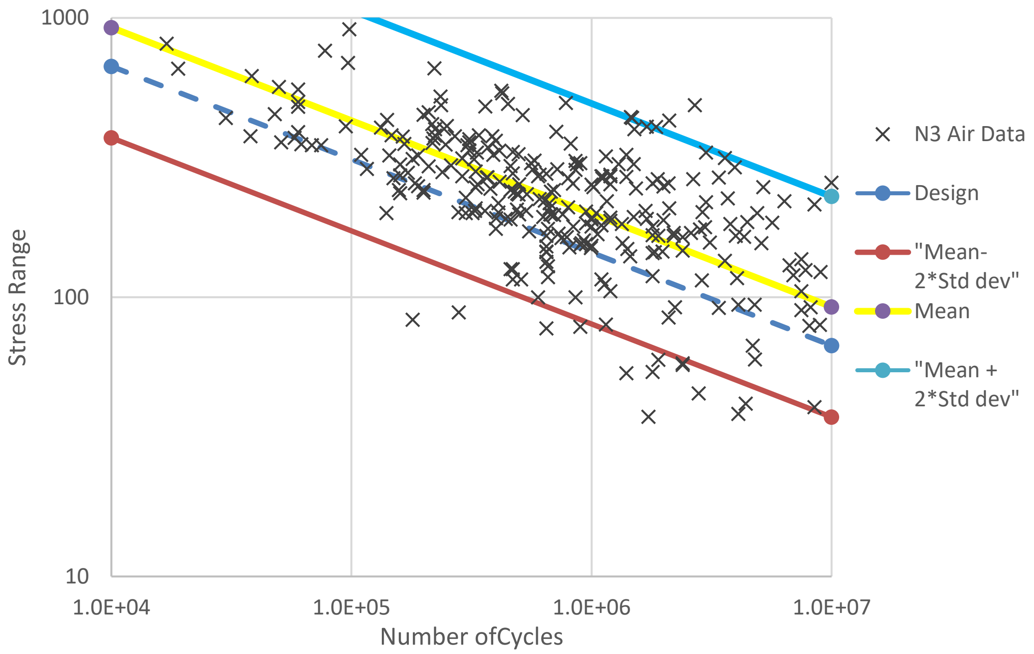


Figure 13 S-N curve for HSS when N3 ≤ 1e7 for full database

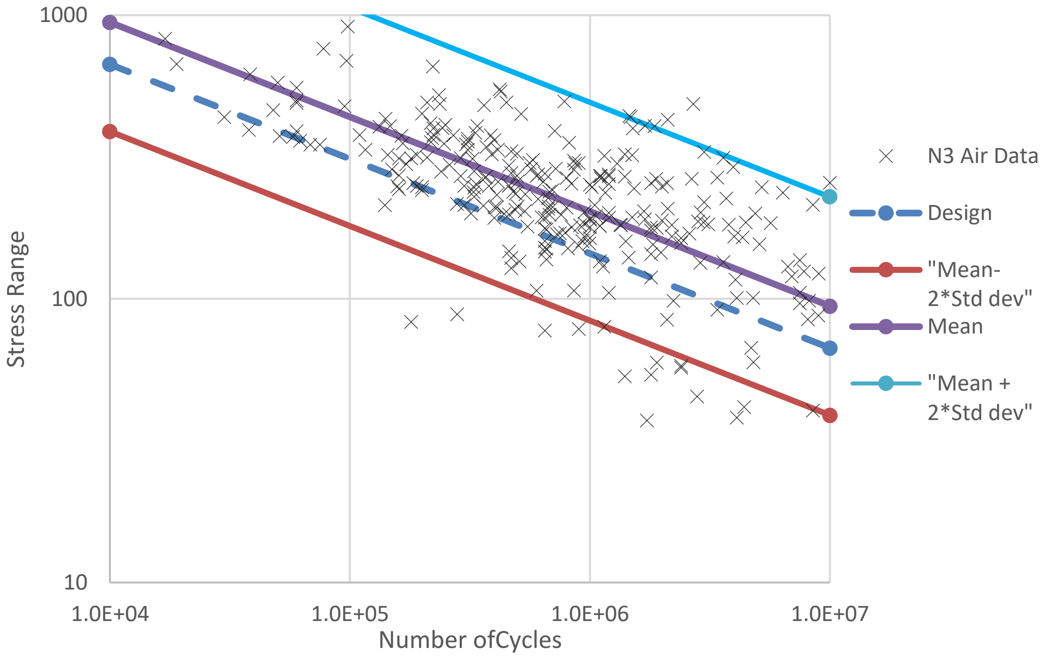


Figure 14 S-N curve for HSS Thickness Corrected when N3 ≤ 1e7 for full database

For the S-N curves from Figure 13 and Figure 14 the data seem to follow the curves at this stage.

Parameters for the S-N curves with values higher than 1e7 are in Table 14 and Table 15.

Table 14 Data for S-N curve when N1 > 1e7

		HSS	HSS Thickness Corrected
Log a		18.66	18.66
Sum error		9.9E-08	9.9E-08
S-N curve Range			
Air	**m**	**Log a**	**Log a**
Design	5	16.13	16.13
Mean	5	18.66	18.66

Since the parameters for the HSS and HSS thickness corrected S-N curve are the same at Table 14 with just one S-N curve to be plotted was alright and shown in Figure 15.

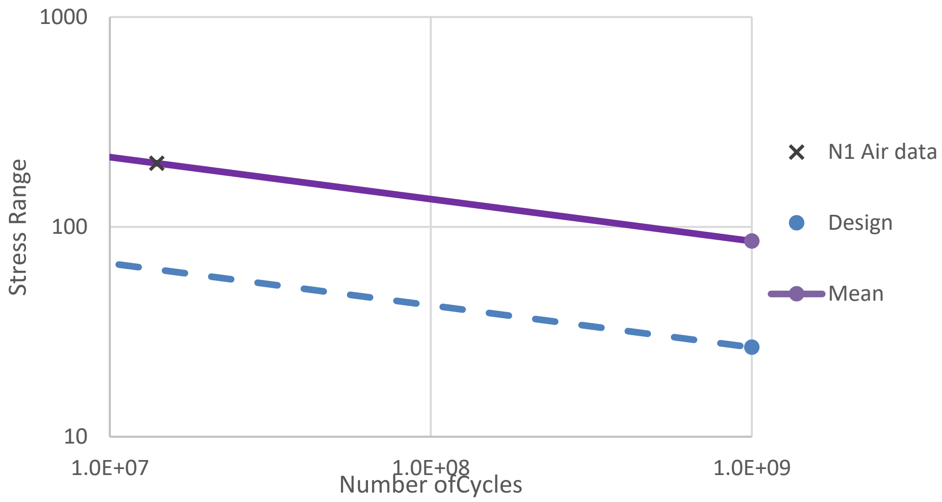


Figure 15 S-N curve for HSS when N1 > 1e7 for full database

The point in Figure 15 is inside the range of the S-N curve.

Table 15 Data for S-N curve when N3 > 1e7

		HSS	HSS Thickness Corrected
Log a		16.91	16.97
Sum error		1.3E+04	1.30E+04
Std Dev		0.789	0.784
S-N curve Range			
Air	**m**	**Log a**	**Log a**
Design	3	16.13	16.13
Mean - 2*Std dev.	3	15.33	15.40
Mean	3	16.91	16.97
Mean + 2*Std dev.	3	18.49	18.54

The parameters from Table 15 are plotted in Figure 16 and Figure 17.

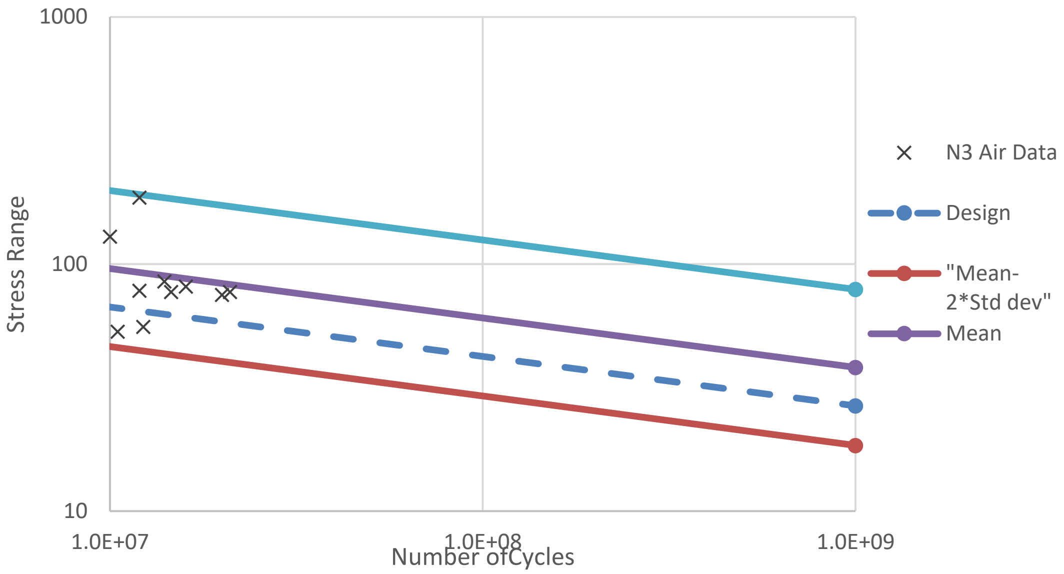


Figure 16 S-N curve for HSS when N3 > 1e7 for full database

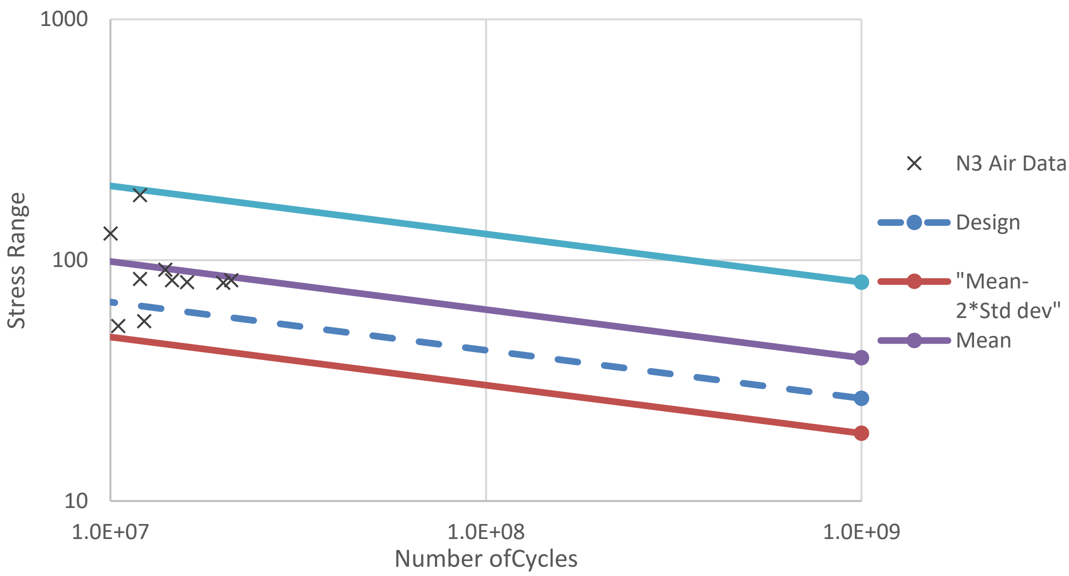


Figure 17 S-N curve for HSS Thickness Corrected when N3 > 1e7 for full database

The data for N3>1e7 in Figure 16 and Figure 17 are fitting well to the range of the S-N curves.

Once the S-N curves for the full database were plotted, the S-N curves for the N1 and N3 data of the "OTH 92 390" [2] were also plotted. For the OTH S-N curves design, a total of 70 values for N1 and 92 for N3 were considered.

Parameters for the S-N curves of the OTH with values lower or equal to 1e7 are in Table 16 and Table 17.

Table 16 OTH 92 390 data for S-N curve when N1 ≤ 1e7

		HSS	HSS Thickness Corrected
Log a		11.68	11.72
Sum error		2.8E+05	2.9E+05
Std Dev		0.463	0.451
S-N curve Range			
Air	**m**	**Log a**	**Log a**
Design	3	12.48	12.48
Mean - 2*Std dev.	3	10.76	10.82
Mean	3	11.68	11.72
Mean + 2*Std dev.	3	12.61	12.62

The parameter from Table 16 is plotted in Figure 18 and Figure 19.

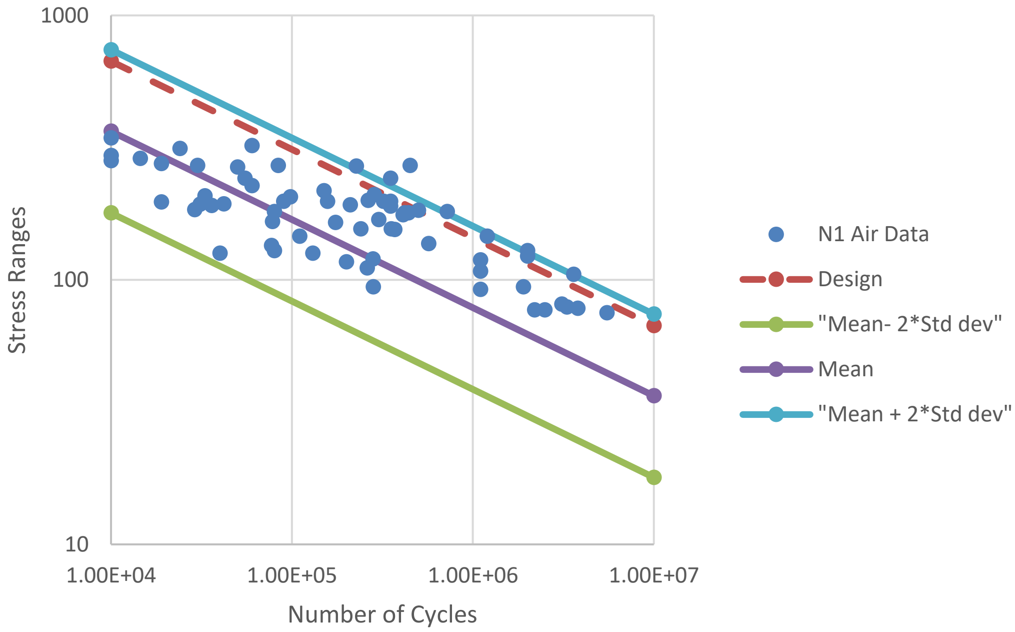


Figure 18 S-N curve for OTH 92 390 with HSS when N1 ≤ 1e7

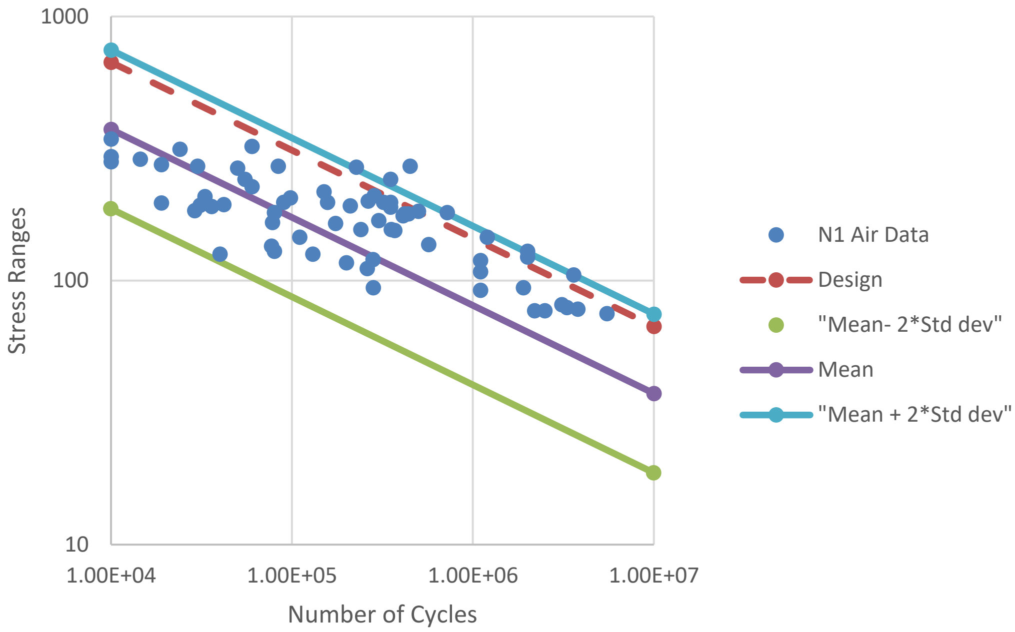


Figure 19 S-N curve for OTH with HSS Thickness Corrected when N1 ≤ 1e7

Data for N1≤1e7 in Figure 18 and Figure 19 are following the S-N curves and inside the ranges.

Table 17 OTH data for S-N curve when N3 ≤ 1e7

		HSS	HSS Thickness Corrected
Log a		12.79	12.83
Sum error		2.0E+05	1.6E+05
Std Dev		0.311	0.270
S-N curve Range			
Air	**m**	**Log a**	**Log a**
Design	3	12.48	12.48
Mean - 2*Std dev.	3	12.17	12.29
Mean	3	12.79	12.83
Mean + 2*Std dev.	3	13.42	13.37

The parameters from Table 17 are plotted in Figure 20 and Figure 21.

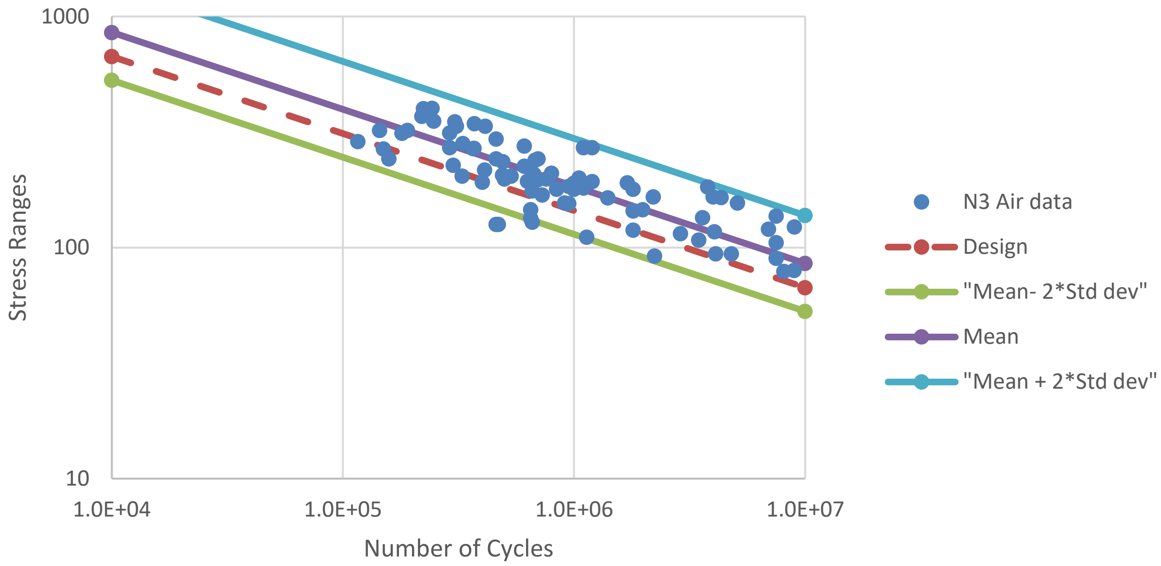


Figure 20 S-N curve for OTH with HSS when N3 ≤ 1e7

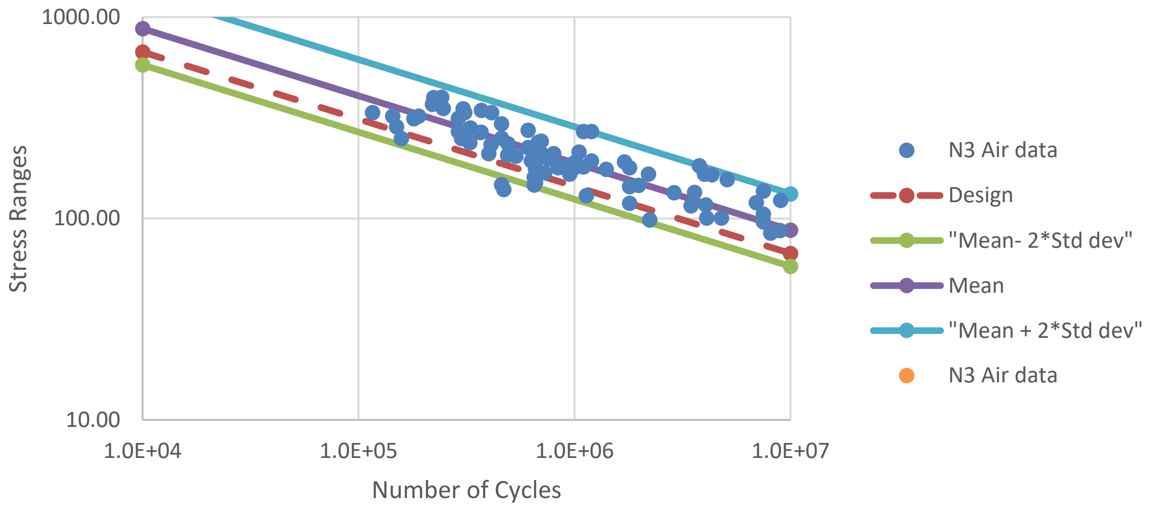


Figure 21 S-N curve for OTH with HSS Thickness Corrected when N3 ≤ 1e7

Data in Figure 20 and Figure 21 fit well to the S-N curves and the data are in range.

Table 18 OTH data for S-N curve when N3 > 1e7

		HSS	HSS Thickness Corrected
Log a		16.86	16.95
Sum error		1.6E+03	1.2E+03
Std Dev		0.373	0.323
S-N curve Range			
Air	**m**	**Log a**	**Log a**
Design	5	16.13	16.13
Mean - 2*Std dev.	5	16.12	16.31
Mean	5	16.86	16.95
Mean + 2*Std dev.	5	17.61	17.60

The parameters from Table 18 are plotted in Figure 22 and Figure 23.

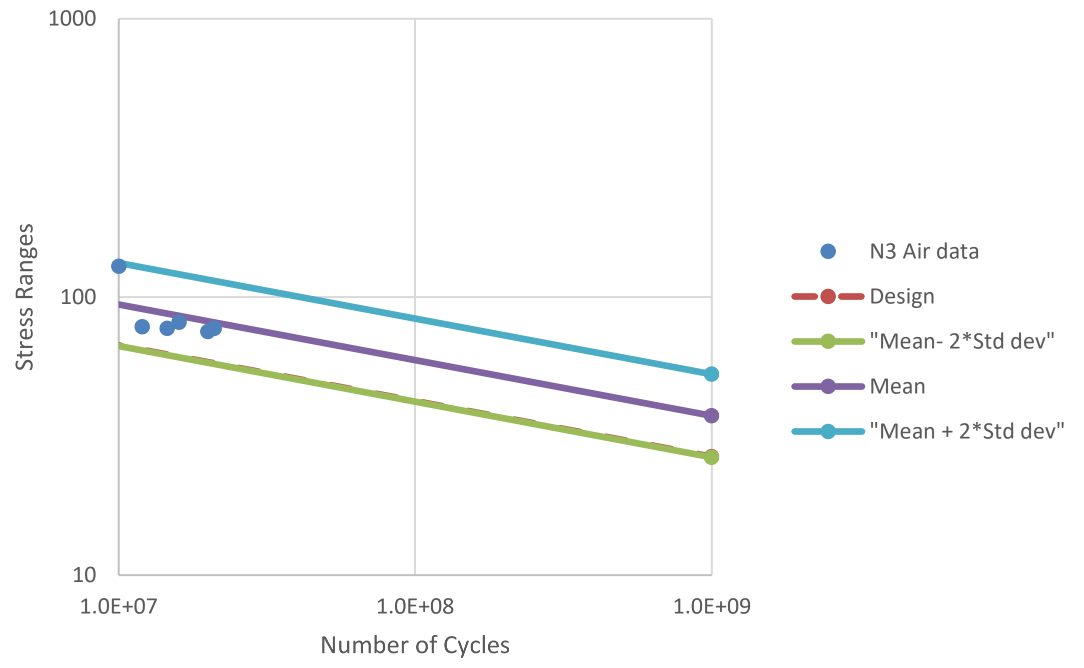


Figure 22 S-N curve for OTH with HSS when N3 > 1e7

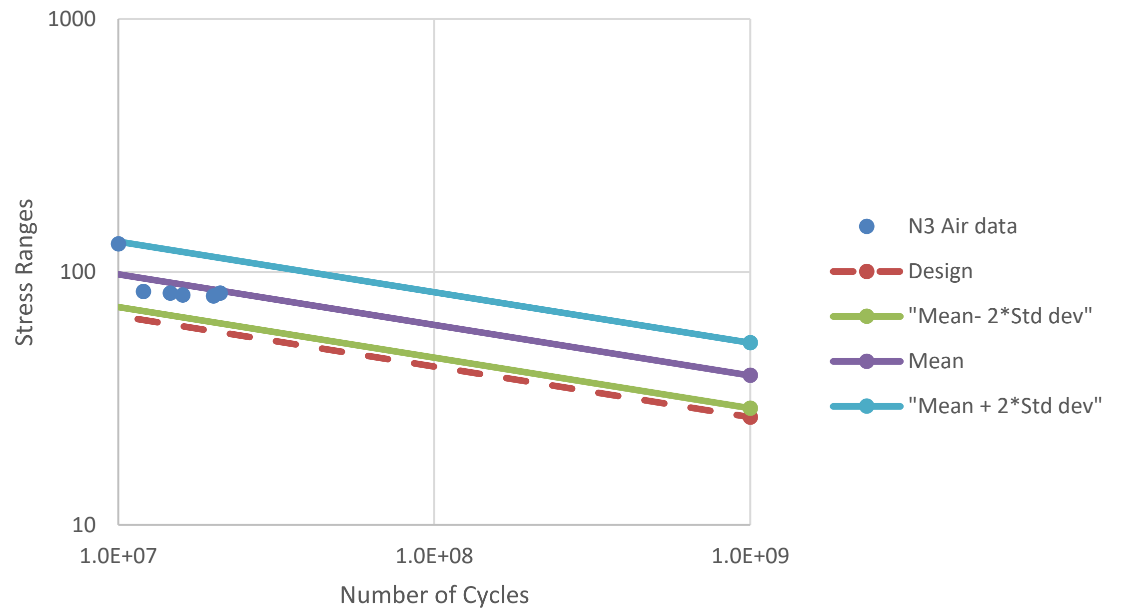


Figure 23 S-N curve for OTH with HSS Thickness Corrected when N3 > 1e7

Data for N3>1e7 in Figure 22 and Figure 23 are in range to the S-N curves.

3.5. Residual life (RE) after through-thickness crack

Residual life through-thickness cracked members evaluated in terms of Re is defined in [3] as:

$$Re = \frac{N_4 - N_3}{N_3} \times 100\% \qquad (18)$$

From the whole database gathered only 335 joints have the Re value calculated and from those values, statistical evaluations were performed. A summary statistics was done and shown in Table 19, and a box and whisker plot was also done to show the values of the summary statistics this can be seen in Figure 24. After that, a frequency histogram and a cumulative frequency were plotted in Figure 25 and Figure 26.

Table 19 Summary statics for Re

Quantity	335
Average	0.495
Median	0.28
Standard deviation	0.743
Minimum	0.01
Maximum	6.73
Lower quartile	0.15
Upper quartile	0.62
Interquartile range	0.47

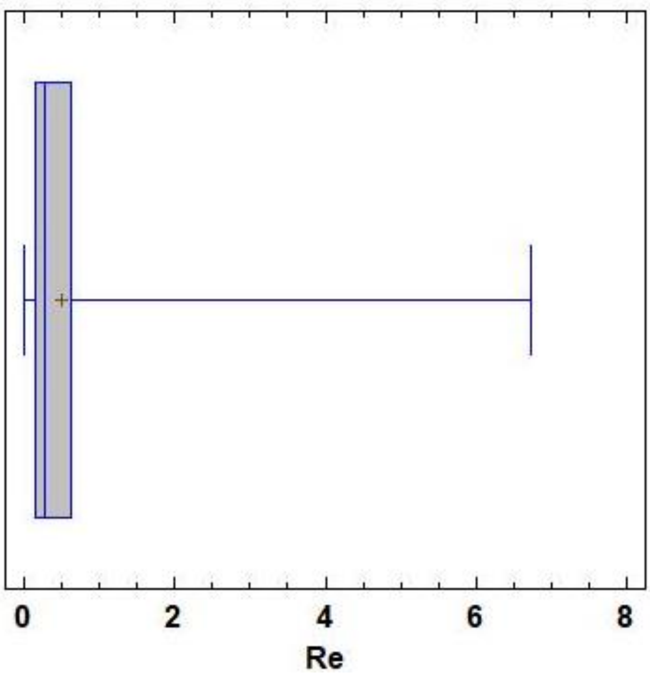


Figure 24 Box-and-Whisker plot for Re

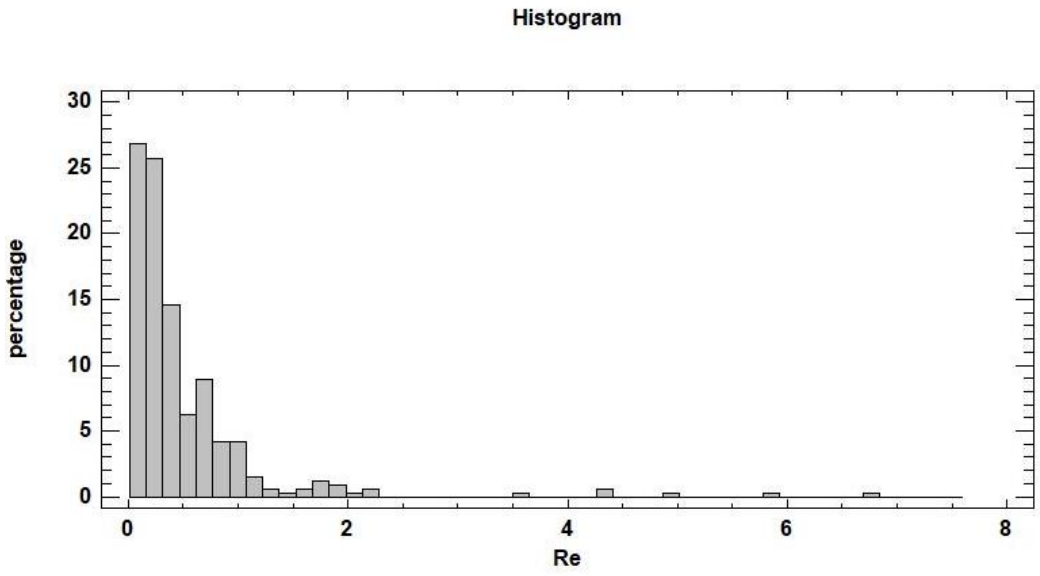


Figure 25 Frequency Histogram Re

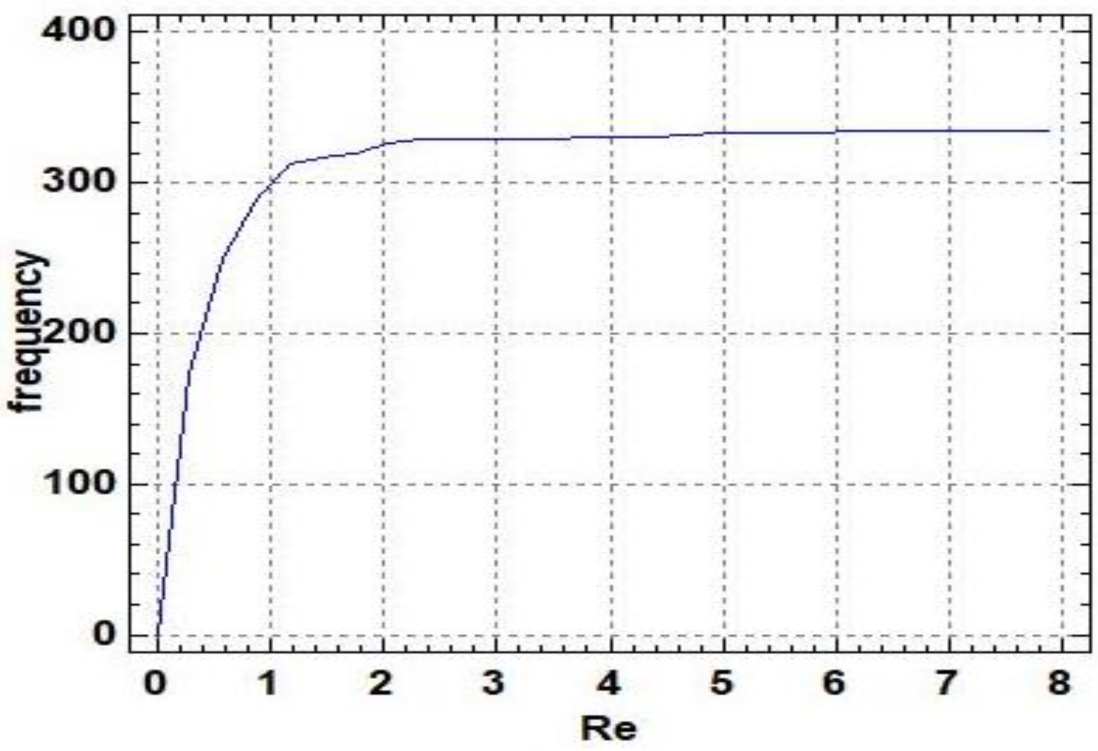


Figure 26 Cumulative Frequency Re

From the frequency histogram can see that most of the Re data is from 0 to 1 and from the cumulative frequency is that almost at 4 it reaches total quantity of points being almost the cumulated 100%.

Re data then was used and plot into different probability distributions to see in which this fits best and can be seen in Figure 27, Figure 28, and Figure 29.

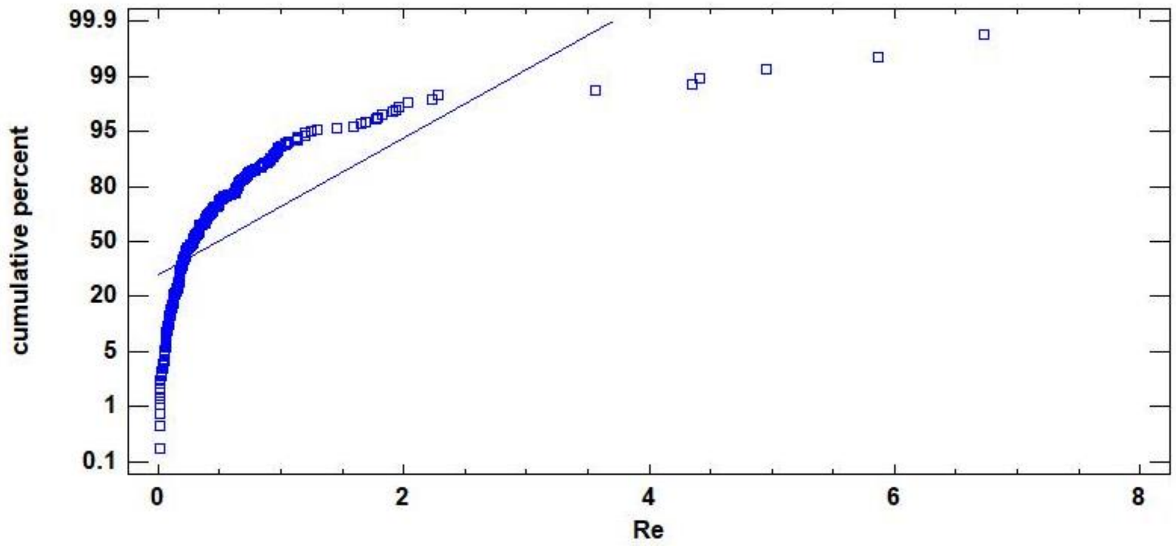


Figure 27 Normal Probability Plot - Re

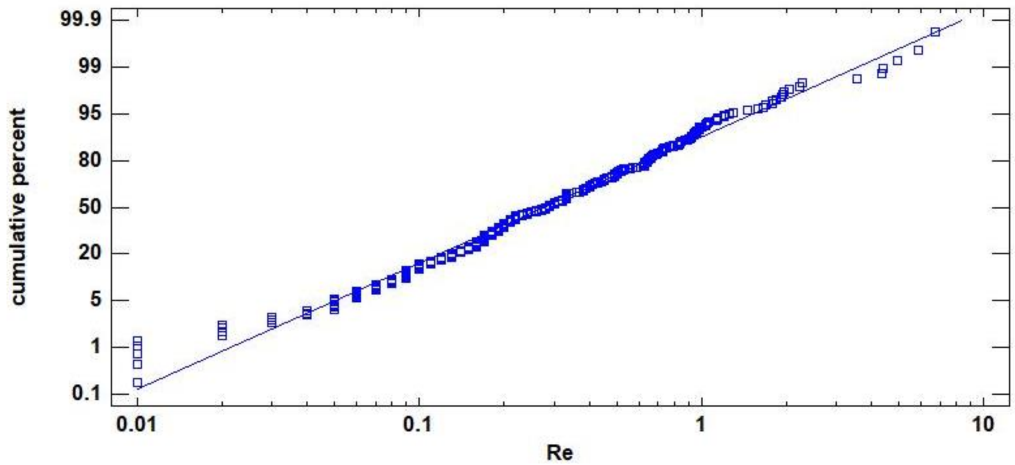


Figure 28 Lognormal Probability Plot - Re

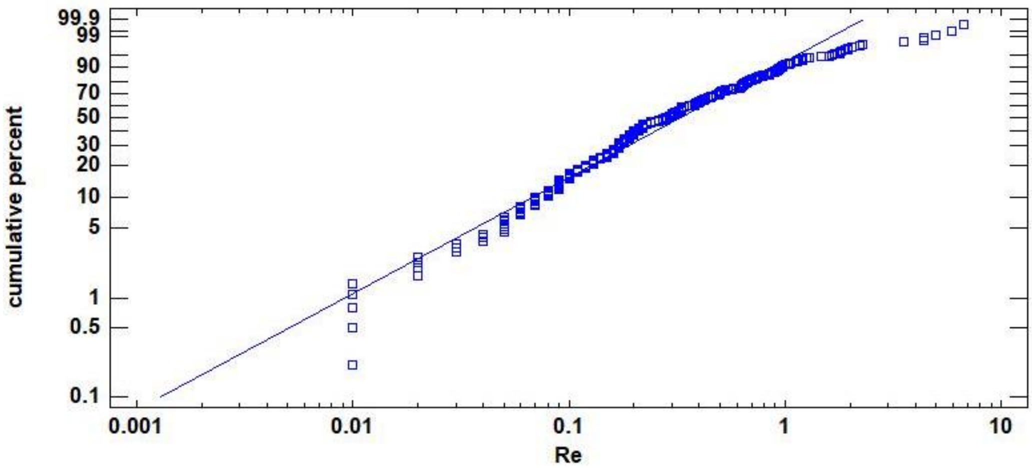


Figure 29 Weibull Probability Plot – Re

From the probability plots, the best fit for the Re data in Figure 28 in which the data follows the linear trendline from the distribution.

3.5.1. Regression analysis - Dependence on parameters:

A simple regression analysis was done for different independent variables all compared to the same dependent variable (Re). In all cases, the results of the fittest model were presented and a plot with the confidence intervals and prediction limits.

After all simple analyses a multiple analysis was performed.

For the plots of the fitted models each of the lines represents a parameter which as from [13] represents the following:

- The blue line is the line of the best fit or prediction equation fitted to the model. This equation depends on the type of model used but it would be used to predict values of dependent variable Y in each case given values of the different independent variables X.

- The green lines or inner bounds in the plots are the confidence intervals for the mean response at X. They describe how well the location of the line has been estimated given the available data. As the size of the sample increases, these bounds will become tighter. Also is noted that the width of the bounds varies as the function of X, with the line estimated most precisely near the average value.

- The grey lines or outer bounds in the plots are the prediction limits for new observations. These describe how precisely one could predict where a single new observation would lie. Regardless of the size of the sample, new observations will vary around the true line with a standard deviation equal to σ.

<u>Simple regression – Thickness vs Re</u>

The total number of data used for each parameter on the analysis: 335 points.
Dependent variable: Re
Independent variable: Thickness
Exponential model: Y = exp (a + b*X)

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	-0.99692	0.0925614	-10.7704	0.0000
Slope	-0.0142861	0.00349817	-4.08387	0.0001

NOTE: intercept = ln(a)

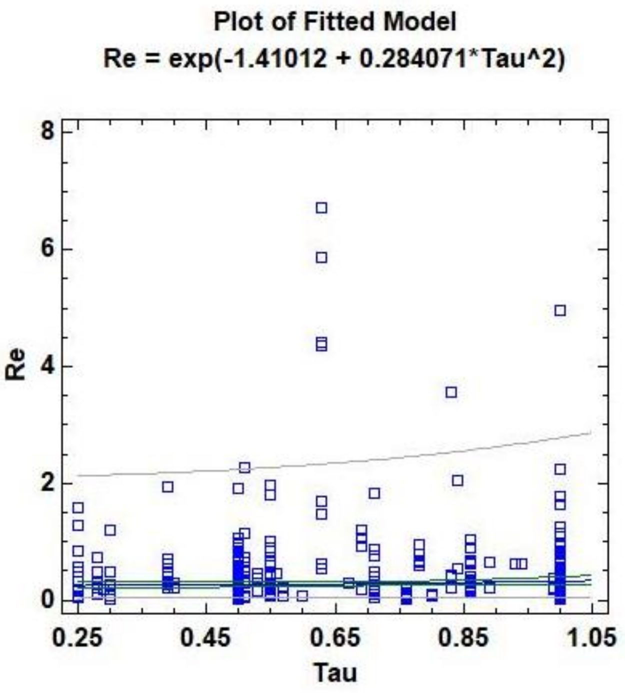
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	19.117	1	19.117	16.68	0.0001
Residual	381.698	333	1.14624		
Total (Corr.)	400.815	334			

Correlation Coefficient = -0.218392
R-squared = 4.76952 percent
R-squared (adjusted for d.f.) = 4.48354 percent
Standard Error of Est. = 1.07063
Mean absolute error = 0.833676
Durbin-Watson statistic = 1.38019 (P=0.0000)
Lag 1 residual autocorrelation = 0.305356

The equation of the fitted model is:

Re = exp (-0.99692 - 0.0142861*Thickness)



Simple regression – β vs Re

The total number of data used for each parameter on the analysis: 328 points.
Dependent variable: Re
Independent variable: Beta
Logarithmic-Y squared-X: Y = exp (a + b*X^2)

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	-1.36134	0.0976701	-13.9382	0.0000
Slope	0.23165	0.180978	1.27999	0.2015

NOTE: intercept = ln(a)

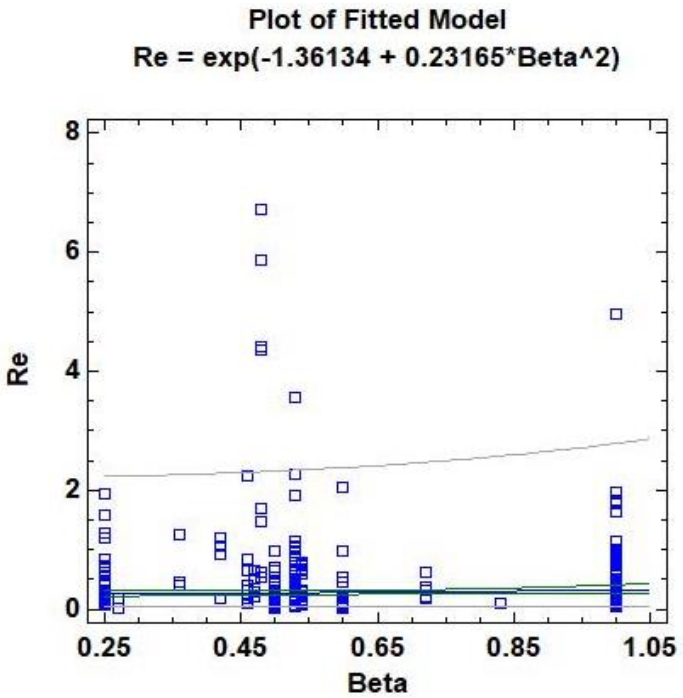
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	1.94132	1	1.94132	1.64	0.2015
Residual	386.278	326	1.1849		
Total (Corr.)	388.219	327			

Correlation Coefficient = 0.0707147
R-squared = 0.500057 percent
R-squared (adjusted for d.f.) = 0.194843 percent
Standard Error of Est. = 1.08853
Mean absolute error = 0.839862
Durbin-Watson statistic = 1.31181 (P=0.0000)
Lag 1 residual autocorrelation = 0.338854

The equation of the fitted model is:

Re = exp (-1.36134 + 0.23165*Beta^2)



Simple regression – τ vs Re

The total number of data used for each parameter on the analysis: 328 points.
Dependent variable: Re
Independent variable: Tau
Logarithmic-Y squared-X: Y = exp (a + b*X^2)

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	-1.41012	0.112089	-12.5803	0.0000
Slope	0.284071	0.182528	1.55631	0.1206

NOTE: intercept = ln(a)

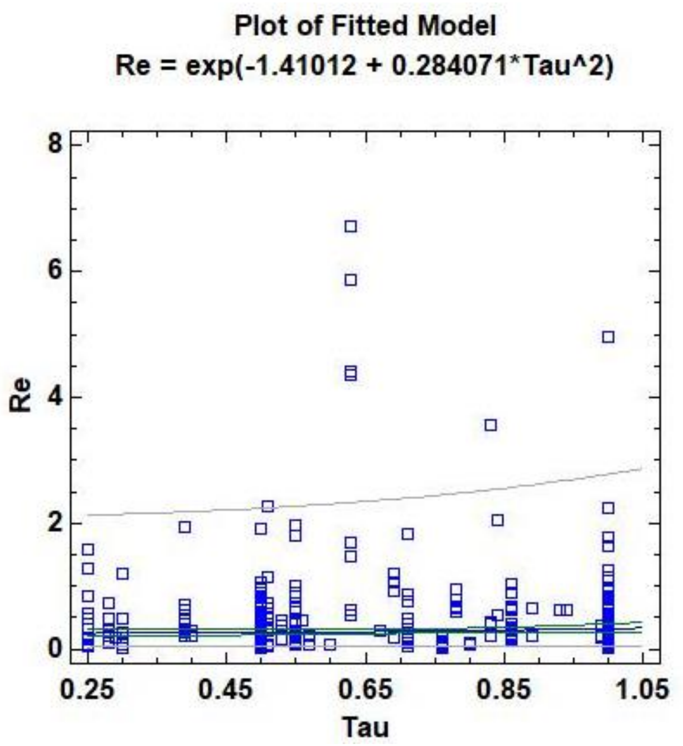
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	2.8631	1	2.8631	2.42	0.1206
Residual	385.356	326	1.18207		
Total (Corr.)	388.219	327			

Correlation Coefficient = 0.0858776
R-squared = 0.737497 percent
R-squared (adjusted for d.f.) = 0.43301 percent
Standard Error of Est. = 1.08723
Mean absolute error = 0.837236
Durbin-Watson statistic = 1.31087 (P=0.0000)
Lag 1 residual autocorrelation = 0.339476

The equation of the fitted model is:

Re = exp (-1.41012 + 0.284071*Tau^2)



Simple regression – γ vs Re

The total number of data used for each parameter on the analysis: 335 points.
Dependent variable: Re
Independent variable: Gamma
S-curve model: Y = exp (a + b/X)

Coefficients

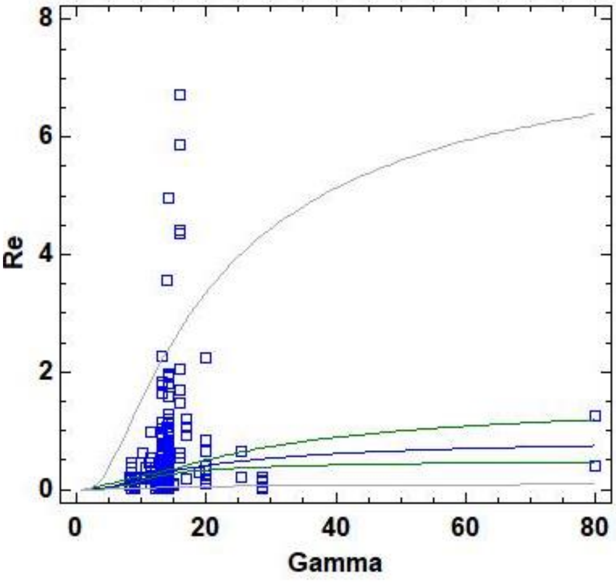
	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	-0.0937322	0.282418	-0.331892	0.7402
Slope	-16.1758	3.73689	-4.32869	0.0000

NOTE: intercept = ln(a)

Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	21.352	1	21.352	18.74	0.0000
Residual	379.463	333	1.13953		
Total (Corr.)	400.815	334			

Plot of Fitted Model
Re = exp(-0.0937322 - 16.1758/Gamma)



Correlation Coefficient = -0.230806
R-squared = 5.32714 percent
R-squared (adjusted for d.f.) = 5.04283 percent
Standard Error of Est. = 1.06749
Mean absolute error = 0.825944
Durbin-Watson statistic = 1.34652 (P=0.0000)
Lag 1 residual autocorrelation = 0.320502

The equation of the fitted model is:

Re = exp (-0.0937322 - 16.1758/Gamma)

Simple regression – N1 vs Re

The total number of data used for each parameter on the analysis: 200 points.
Dependent variable: Re
Independent variable: N1
Logarithmic-Y square root-X model: Y = exp (a + b*sqrt(X))

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	-0.909972	0.102455	-8.88171	0.0000
Slope	-0.000456661	0.000124855	-3.65753	0.0003

NOTE: intercept = ln(a)

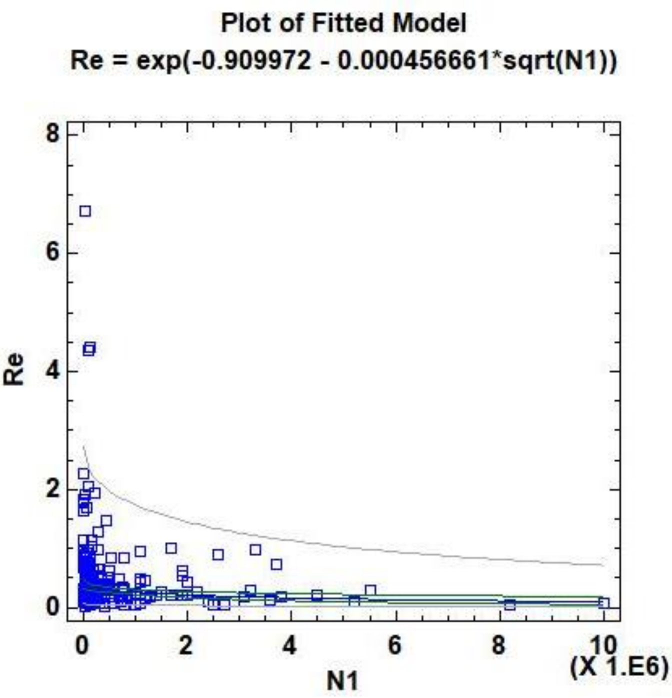
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	12.5432	1	12.5432	13.38	0.0003
Residual	185.651	198	0.93763		
Total (Corr.)	198.194	199			

Correlation Coefficient = -0.25157
R-squared = 6.32874 percent
R-squared (adjusted for d.f.) = 5.85566 percent
Standard Error of Est. = 0.968313
Mean absolute error = 0.751356
Durbin-Watson statistic = 1.28437 (P=0.0000)
Lag 1 residual autocorrelation = 0.350467

The equation of the fitted model is:

Re = exp (-0.909972 - 0.000456661*sqrt(N1))



Simple regression – N3 vs Re

The total number of data used for each parameter on the analysis: 335 points.
Dependent variable: Re
Independent variable: N3
Logarithmic-X model: Y = a + b*ln(X)

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	1.72907	0.391664	4.41468	0.0000
Slope	-0.0912713	0.0288037	-3.16874	0.0017

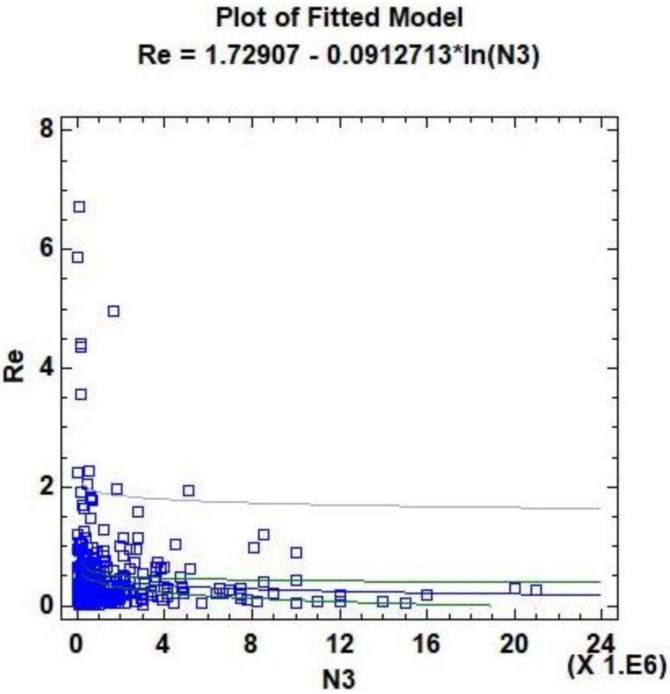
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	5.40345	1	5.40345	10.04	0.0017
Residual	179.202	333	0.538144		
Total (Corr.)	184.605	334			

Correlation Coefficient = -0.171086
R-squared = 2.92703 percent
R-squared (adjusted for d.f.) = 2.63551 percent
Standard Error of Est. = 0.733583
Mean absolute error = 0.399116
Durbin-Watson statistic = 1.04895 (P=0.0000)
Lag 1 residual autocorrelation = 0.474619

The equation of the fitted model is:

Re = 1.72907 - 0.0912713*ln(N3)



Simple regression – HSS vs Re

The total number of data used for each parameter on the analysis: 313 points.
Dependent variable: Re
Independent variable: HSS
Logarithmic-Y square root-X model: Y = exp (a + b*sqrt(X))

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	-1.71681	0.229114	-7.49323	0.0000
Slope	0.0288468	0.0146587	1.9679	0.0500

NOTE: intercept = ln(a)

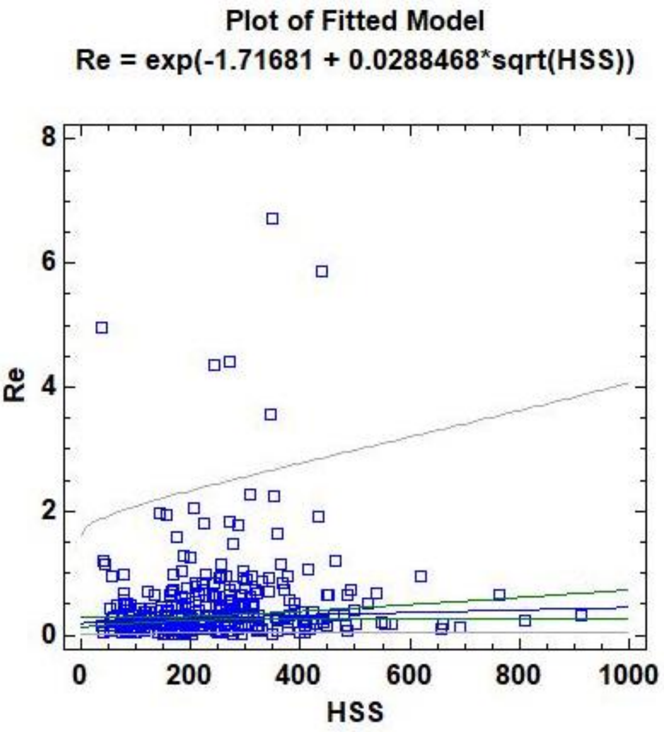
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	4.6304	1	4.6304	3.87	0.0500
Residual	371.855	311	1.19568		
Total (Corr.)	376.486	312			

Correlation Coefficient = 0.110901
R-squared = 1.2299 percent
R-squared (adjusted for d.f.) = 0.91231 percent
Standard Error of Est. = 1.09347
Mean absolute error = 0.839405
Durbin-Watson statistic = 1.31949 (P=0.0000)
Lag 1 residual autocorrelation = 0.335279

The equation of the fitted model is:

Re = exp (-1.71681 + 0.0288468*sqrt (HSS))



<u>Simple regression – HSS thickness corrected vs Re</u>

The total number of data used for each parameter on the analysis: 313 points.
Dependent variable: Re
Independent variable: HSS thickness corrected
Double square root model: Y = (a + b*sqrt(X)) ^2

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	0.487757	0.0763216	6.39081	0.0000
Slope	0.00800801	0.00482882	1.65838	0.0982

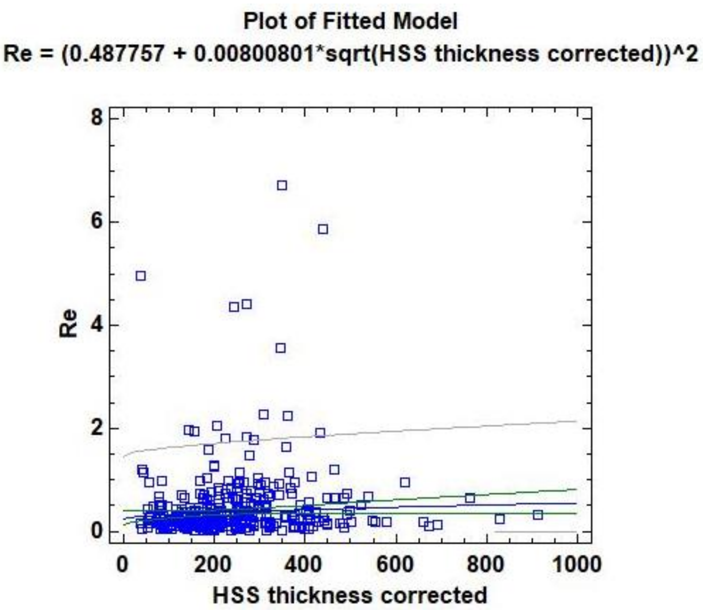
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	0.35155	1	0.35155	2.75	0.0982
Residual	39.7539	311	0.127826		
Total (Corr.)	40.1054	312			

Correlation Coefficient = 0.093625
R-squared = 0.876564 percent
R-squared (adjusted for d.f.) = 0.55784 percent
Standard Error of Est. = 0.357528
Mean absolute error = 0.251544
Durbin-Watson statistic = 1.13017 (P=0.0000)
Lag 1 residual autocorrelation = 0.431975

The equation of the fitted model is:

Re = (0.487757 + 0.00800801*sqrt (HSS thickness corrected)) ^2



Multiple regression Re:

The total number of data used for each parameter on the analysis: 186 points.
Dependent variable: Re
Independent variables: Thickness, Beta, Tau, Gamma, N1, N3, HSS, HSS Thickness corrected

		Standard	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
CONSTANT	-0.192894	0.625912	-0.30818	0.7583
Thickness	0.00960525	0.00830115	1.1571	0.2488
Beta	-0.497924	0.298064	-1.67053	0.0966
Tau	0.375304	0.323866	1.15883	0.2481
Gamma	0.0461048	0.033094	1.39315	0.1653
N1	-4.63262E-8	5.86949E-8	-0.789271	0.4310
N3	-1.86815E-8	2.44026E-8	-0.765552	0.4450
HSS	0.0282471	0.013913	2.03027	0.0438
HSS Thickness corrected	-0.027679	0.0136947	-2.02115	0.0448

Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	9.24477	8	1.1556	2.23	0.0273
Residual	91.7154	177	0.518166		
Total (Corr.)	100.96	185			

R-squared = 9.15684 percent
R-squared (adjusted for d.f.) = 5.05094 percent
Standard Error of Est. = 0.719838
Mean absolute error = 0.383774
Durbin-Watson statistic = 1.207 (P=0.0000)
Lag 1 residual autocorrelation = 0.394068

The equation of the fitted model is:

Re = -0.192894 + 0.00960525*Thickness - 0.497924*Beta + 0.375304*Tau + 0.0461048*Gamma - 4.63262E-8*N1 - 1.86815E-8*N3 + 0.0282471*HSS - 0.027679*HSS Thickness corrected

3.6. Comparison with OTH 92 390

From the report of the OTH 92 390 [2], there were only compared the tubular joints tested in air conditions.

The first discover that was made was realizing an error in the report where they mention that sum of tested joints from 20 mm to 32 mm was a total of 21 joints but, there were only 20 of them.

Table 20 Comparison of summary tubular joints tested

Chord wall thickness	Number of Joints in the Report	Number of Joints in the Database
16 mm to 19 mm	59	59
20 mm to 32 mm	21	20
40 mm to 50 mm	6	6
70 mm to 80 mm	7	7
Total Number of Joints	**93**	**92**

From those 92 joints, only 81 joints have values for Re, and so from those, a mean of 44.7% and a standard deviation of 0.411 were obtained.

After that, the different S-N curves of the specimens in air were plotted with the end to compare them with the ones in the report.

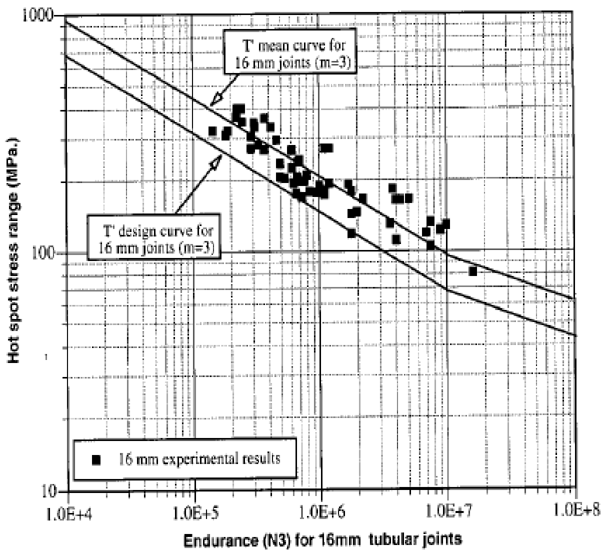


Figure 30 Experimental data for 16mm thick tubular joints [2]

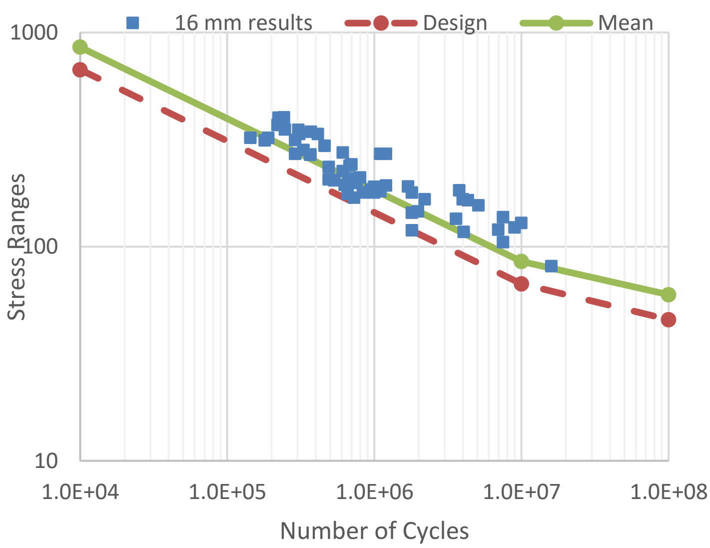


Figure 31 Experimental data for 16mm thick tubular joints database

For the 16 mm results the S-N curves almost similar the only small difference between the plots is the point when the cycles are over 1e7 that is over the curve mean design.

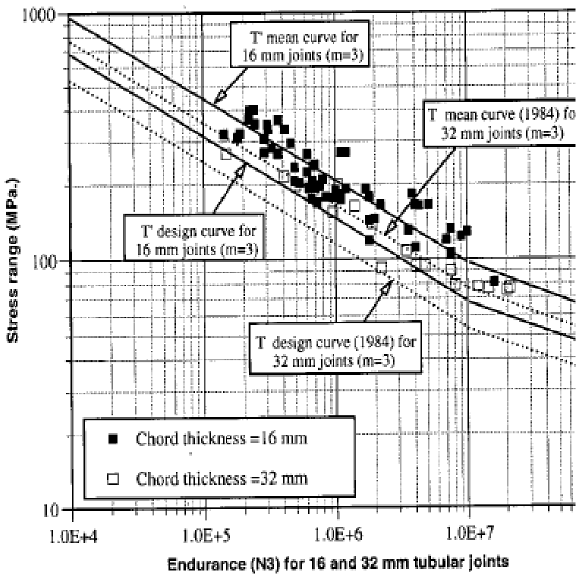


Figure 32 Effect of chord thickness on fatigue performance of tubular joints in air [2]

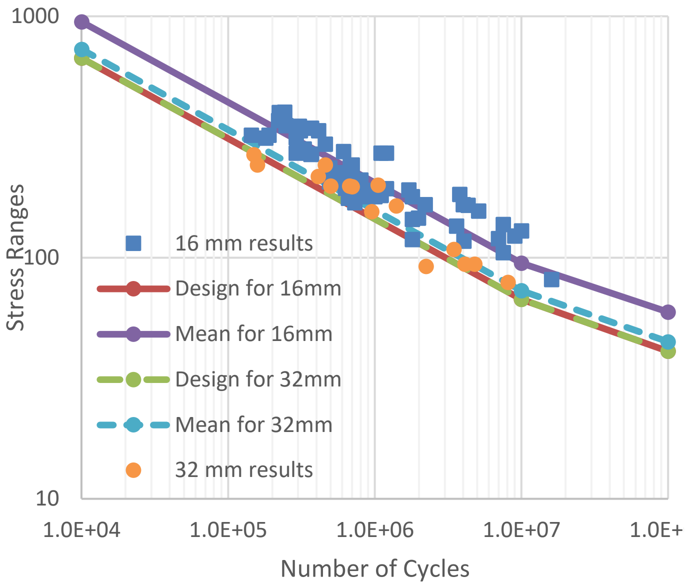


Figure 33 Effect of chord thickness on fatigue performance of tubular joints in air database

From Figure 32 and Figure 33 can observe that the design curve for data with chord thickness equal to 32 mm is different than the one in the report, in which the design curve for the database gets a higher value than in the report. All the other curves and data points are equal from the report to the database.

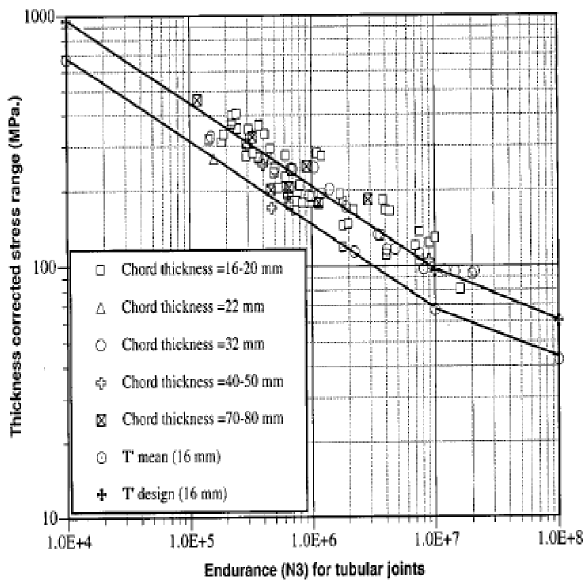


Figure 34 Thickness corrected fatigue performance of tubular joints in air [2]

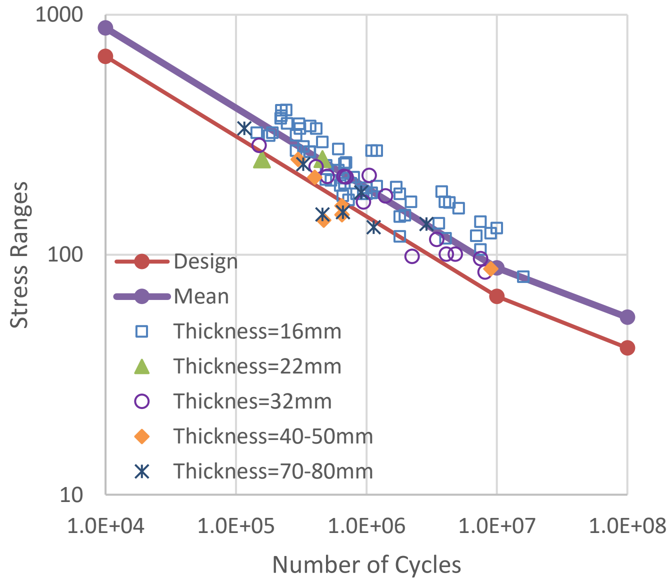


Figure 35 Thickness corrected fatigue performance of tubular joints in air database

From Figure 34 and Figure 35 the curves and points are identically between the report and the ones in the database.

3.7. Comparison with Zhang and Wintle

This section starts with a statistic evaluation on Re then continue plotting frequency histogram and cumulative distribution of the data to compare it with the plots on the Zhang and Stacey report [15] after the Re data is plotted in different distributions to see which is probability follows the data and for last a comparison from the conclusions from the Zhang and Wintle report [3] was conducted in this point only the conclusions can be appreciated but in Appendix 2: Analysis Zhang and Wintle the values from the report to the calculated ones and their difference can be seen.

First, statistics from the Re specimens on the database from Zhang and Wintle report was performed and the result of this is presented in Table 21 as a comparison to the values from the report.

Table 21 Comparison Re statistics from report to database

	Report	**Database**
Sample size	281	285
Mean Re	0.443	0.438
Std dev	0.531	0.521
Cov	1.2	1.188

The probability distribution and a cumulative frequency for all the Re of the data collected were plotted with the intention to compare it with the plots that are showed in the Zhang and Stacey report [15]. The report plots are in Figure 36 and Figure 38 meanwhile the plots from the database are in Figure 37 and Figure 39.

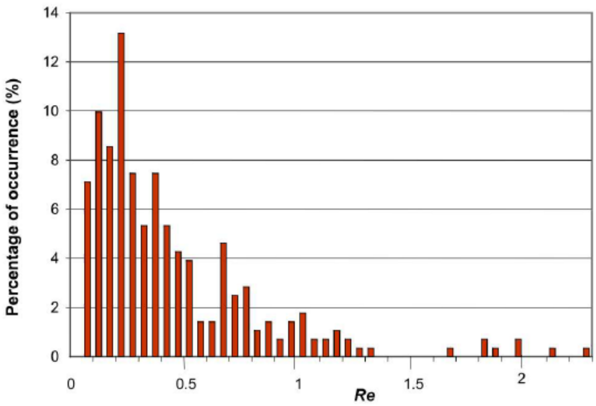


Figure 36 Probability distribution for Re of [15]

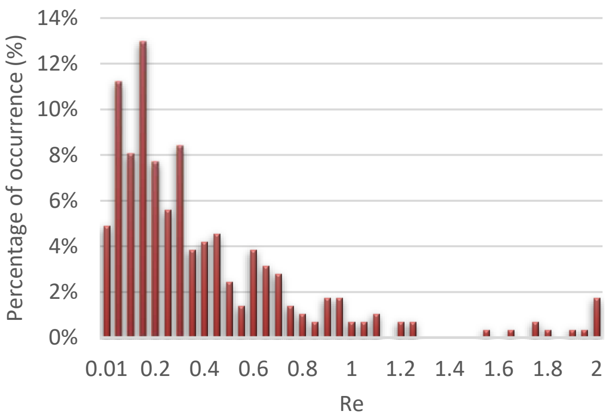


Figure 37 Probability distribution for Re of the database

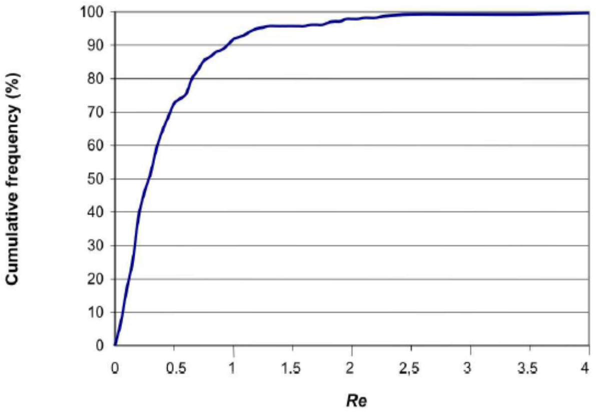


Figure 38 Cumulative frequency distribution of Re of [15]

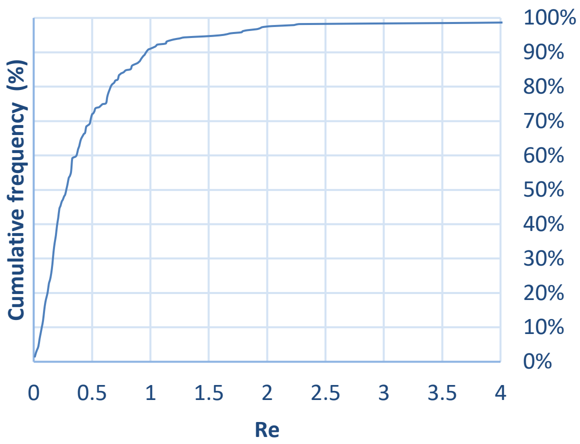


Figure 39 Cumulative distribution of Re of the database

The probability distributions almost look the same but they present some minor differences meanwhile the cumulative frequency distribution plots are the same.

A summary statistics for the 285 values of Re gathered was performed and the results are in Table 22.

Table 22 Summary Statistics for Re of Zhangs

Count	285
Average	0.439825
Standard deviation	0.520467
Coeff. of variation	118.335%
Minimum	0.01
Maximum	4.95
Range	4.94
Stnd. skewness	27.3184
Stnd. kurtosis	85.283

Values of Re are plotted in probability distributions which are in Figure 40, Figure 41, and Figure 42 this with the intention to see which probability is the best fitted but from the standards of skewness and kurtosis from statistic evaluation results, we can expect that the data will not fit a normal distribution.

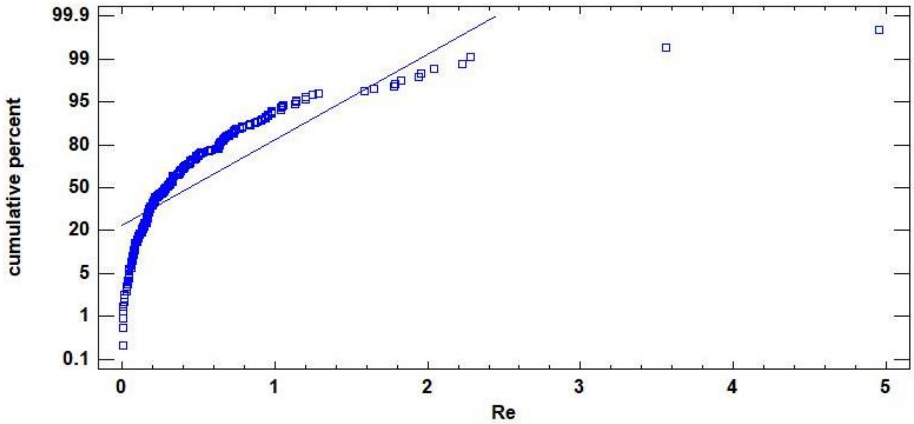


Figure 40 Normal Probability Plot of Re from Zhang collected database

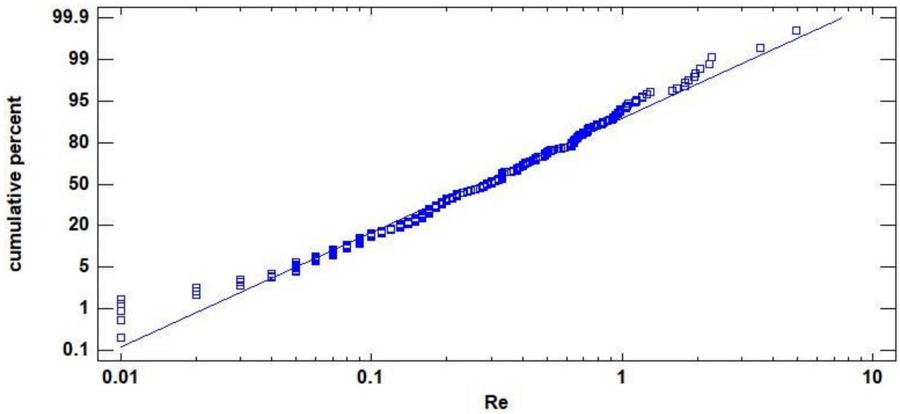


Figure 41 Lognormal Probability Plot of Re from Zhang collected database

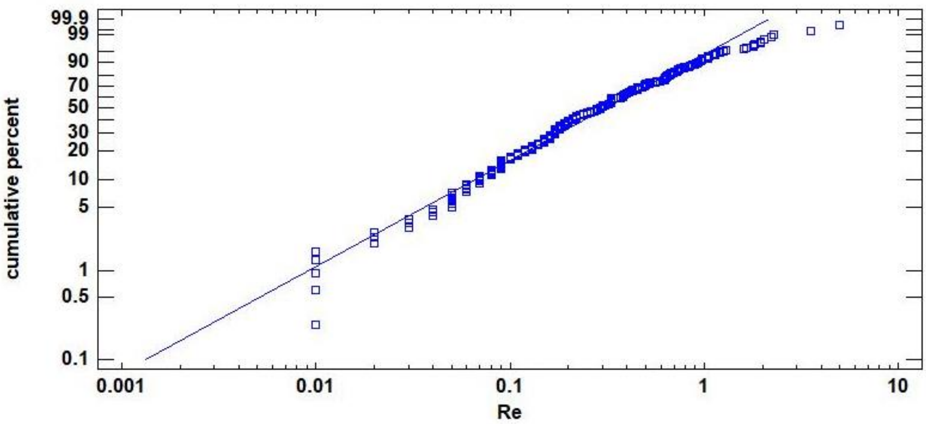


Figure 42 Weibull Probability Plot of Re from Zhang collected database

As expected the data didn't fit the normal distribution and the best fit was the lognormal distribution in which from Figure 41 can see the data follows the linear trendline.

A comparison from the conclusions from Zhang and Wintle's report to the collected database of them are in Table 23 and Table 24. For this comparison, previous calculations with the data gathered were conducted from different effects and parameters established on the "Zhang and Wintle Report" [3] the results obtained and differences from these calculations can be seen in distinct tables shown in Appendix 2: Analysis Zhang and Wintle.

Table 23 Similarities with conclusions from Zhang and Wintle report

Zhang and Wintle conclusions [3]	Present conclusion
Mean value or Re was 44.3%. The ratio N4/N3 is 1.38 and 1.25 for the mean and mead-2SD curves respectively. However, the data were widely scattered.	The mean value of Re in this study (43.8%) agrees reasonably well with Zhang and Wintle (44.3%).
Under axial loading, the stress ratio did not show a significant influence on Re.	Mean Re value from 0.22 increases slightly to 0.277 but not to a significant extent when the stress ratio is -1.
β did not exhibit a significant effect on Re under axial and OPB loadings.	Re with β under OPB still doesn't show any significant influence.
The effect of chord wall thickness on Re depends on the loading mode. Re was not noticeably influenced by chord thickness under axil loading until the chord wall exceeds 32mm. However, it decreased under OPB loading and increased under IPB loading (for both constant and variable amplitude loads) with increasing chord wall thickness (T from 6mm to 16mm).	Re under AX didn't present any relevant change as the chord wall thickness increase, for the other loading modes still the same effect as the one presented in the report.
Under OPB loading, T joints achieved a higher Re value than K/KT joints when compared at a chord wall thickness of 6mm. However, the difference in Re between the two types of joints became small when compared at a chord thickness of 16mm.	The difference Re value for T and K/KT joints under OPB with a chord thickness of 6.3 mm becomes small. As for the chord of 16mm didn't find any K/KT joints with this.
PWHT did not significantly influence Re values for a chord wall thickness T≤32mm but increased Re when T was 76mm	PWHT continues not showing any significant influence on Re.
The effect of internal stiffeners on Re depended on the design of the stiffener and the weld root quality. A higher Re value is expected if cracking occurs at the weld toe on the outer surface of the chord or brace.	For the stiffeners effect still the same results as the report.
The effect of the variable amplitude loads on Re depends on loading modes. Higher Re values at two-chord sizes were achieved under axial loading. However, under IPB, variable amplitude loading decrease Re at a small chord size (T=6mm) but increased Re at a medium chord size (T=16mm)	The effect of the amplitude presents the same results as the report.
The effect of a compressive end load on the chord on Re also depends on the loading mode. It increased the Re under AX. The limited tests under IPB suggested that it decreased Re at a chord thickness of 6mm but increased the Re value at a chord thickness of 16mm. the compressive end load increased Re under OPB loading for two sizes.	The compressive load effect on the chord presents the same results as the report.
Girth welded joints in plain tubes gave a low Re value, with a mean of only 8.6%	Girth welded joints don't present any relative change as in the report. The mean Re value change to 8.4%

Table 24 Differences with conclusions from Zhang and Wintle report

Zhang and Wintle conclusions [3]	Present conclusion
Re was found to decrease with increasing values of τ, especially under OPB.	Didn't find any value of Re when τ is equal to 0.6 under OPB.
Compared to axial loadings, higher Re values were achieved under OPB and IPB loadings, especially under OPB loading for joints with a small chord size.	Re for T joints under AX, IPB, and OPB present the same results as the ones in the report but K and KT joints have a noticeable difference this under AX increasing its value by more than 10% and OPB over 6%
Non-overlapped K/KT joints appeared to have a higher Re value when compared to overlapped ones.	Overlapped K/KT joints mean Re increase from 0.287 to 0.668 and their value is now higher than to the Non-overlapped whose Re value remain as 0.65.
No significant difference in Re values between T and Y joints under axial loading was found.	Re means value for T joints increase more than double from 0.289 to 0.621 and for the mean Re for Y joints it decreased slightly from 0.352 to 0.242.
Limited test indicated that a normal weld profile had a higher Re value when compared to other weld profiles. Results from several investigations suggested that weld toe grinding reduces the Re value.	The Re for the normal weld decreases slightly but makes that the AWS D1.1 profile maintain its value which causes to be the higher Re for the weld profiles. Meanwhile, results from the weld toe grinding continue suggesting that this effect reduces the Re value.
Specimens tested in free seawater corrosion and cathodic protection had a higher Re	K and KT specimens tested in seawater-free corrosion have the lowest Re value compares to in Air and cathodic protections ones all under OPB specimens. As for the T joints, specimens under AX in air environment increase the Re value.
The HSS range magnitude did not show a noticeable effect on Re under any of the three loading modes.	Values of Re show an increase when the HSS range magnitude is under IPB. For HSS<200 mean Re goes from 0.87 to 1.423 For HSS≥200 mean Re goes from 0.784 to 1.25

3.8. N1/N3

Is considered as the fraction of life from when appears the initial first sign of a crack in the element until this goes through the plate.

<u>Simple regression – Thickness vs N1/N3</u>

Dependent variable: N1/N3
Independent variable: Thickness
Squared-Y logarithmic-X model: Y = sqrt (a + b*ln(X))

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	0.335607	0.0715675	4.68938	0.0000
Slope	-0.0663218	0.0264566	-2.50681	0.0133

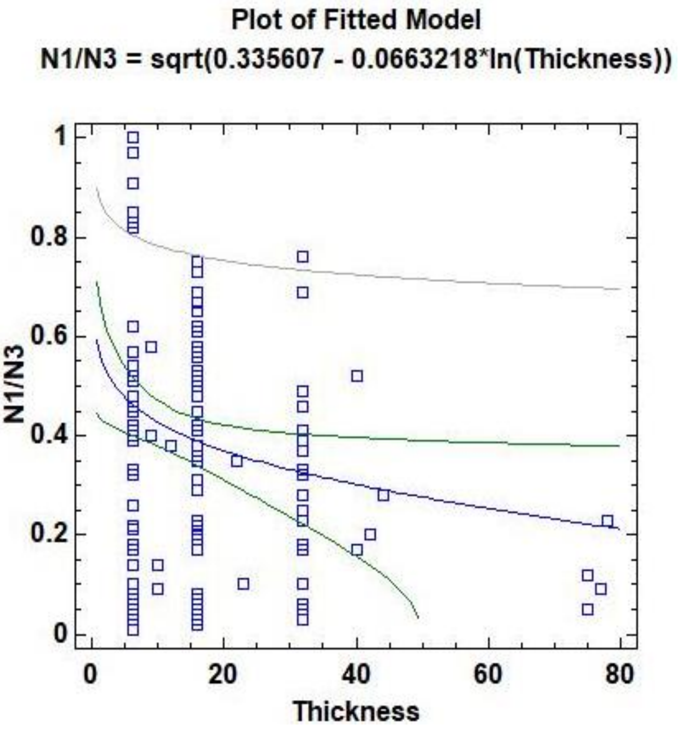
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	0.295511	1	0.295511	6.28	0.0133
Residual	6.81865	145	0.0470251		
Total (Corr.)	7.11416	146			

Correlation Coefficient = -0.20381
R-squared = 4.15384 percent
R-squared (adjusted for d.f.) = 3.49283 percent
Standard Error of Est. = 0.216853
Mean absolute error = 0.158015
Durbin-Watson statistic = 1.20597 (P=0.0000)
Lag 1 residual autocorrelation = 0.395056

The equation of the fitted model is:

N1/N3 = sqrt (0.335607 - 0.0663218*ln (Thickness))



Simple regression – β vs N1/N3

Dependent variable: N1/N3
Independent variable: Beta
S-curve model: Y = exp (a + b/X)

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	-1.1755	0.243105	-4.83535	0.0000
Slope	-0.278911	0.122108	-2.28413	0.0238

NOTE: intercept = ln(a)

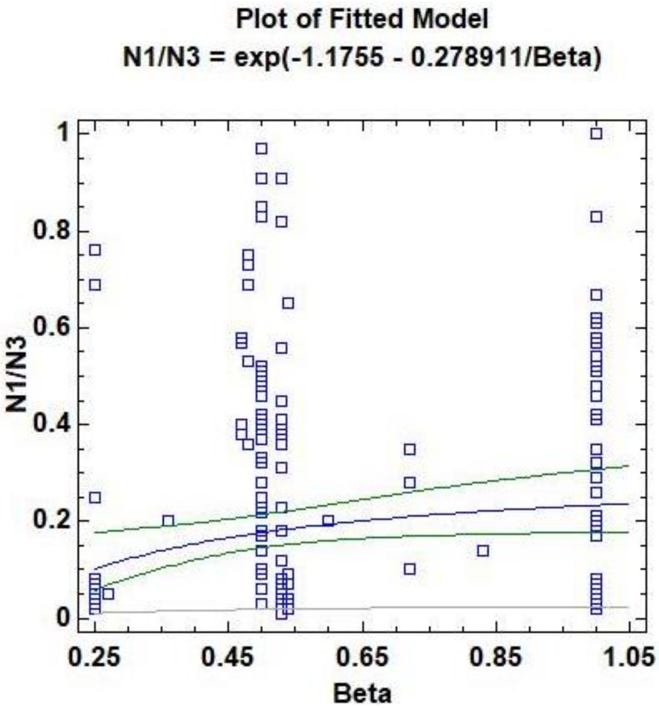
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	6.84853	1	6.84853	5.22	0.0238
Residual	190.337	145	1.31267		
Total (Corr.)	197.185	146			

Correlation Coefficient = -0.186364
R-squared = 3.47314 percent
R-squared (adjusted for d.f.) = 2.80744 percent
Standard Error of Est. = 1.14572
Mean absolute error = 0.985134
Durbin-Watson statistic = 0.671629 (P=0.0000)
Lag 1 residual autocorrelation = 0.663501

The equation of the fitted model is:

N1/N3 = exp (-1.1755 - 0.278911/Beta)



Simple regression – τ vs N1/N3

Dependent variable: N1/N3
Independent variable: Tau
Square root-Y reciprocal-X model: Y = (a + b/X) ^2

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	0.527362	0.0556995	9.46798	0.0000
Slope	-0.0162906	0.0298896	-0.545026	0.5866

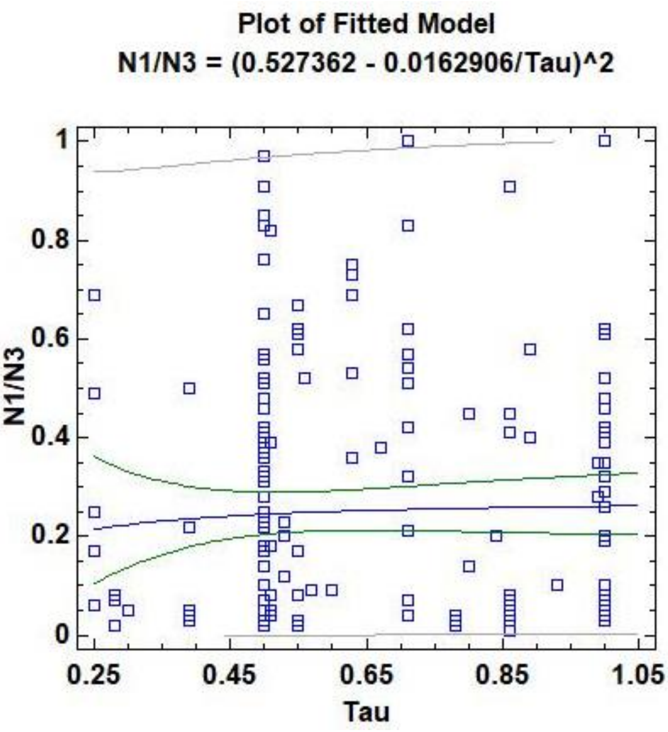
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	0.0180373	1	0.0180373	0.30	0.5866
Residual	8.80452	145	0.0607208		
Total (Corr.)	8.82255	146			

Correlation Coefficient = -0.0452157
R-squared = 0.204446 percent
R-squared (adjusted for d.f.) = -0.483799 percent
Standard Error of Est. = 0.246416
Mean absolute error = 0.214048
Durbin-Watson statistic = 0.76412 (P=0.0000)
Lag 1 residual autocorrelation = 0.616921

The equation of the fitted model is:

N1/N3 = (0.527362 - 0.0162906/Tau) ^2



Simple regression – γ vs N1/N3

Dependent variable: N1/N3
Independent variable: Gamma
Square root-Y squared-X model: Y = (a + b*X^2) ^2

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	0.399064	0.0655239	6.09036	0.0000
Slope	0.000509454	0.000317505	1.60456	0.1108

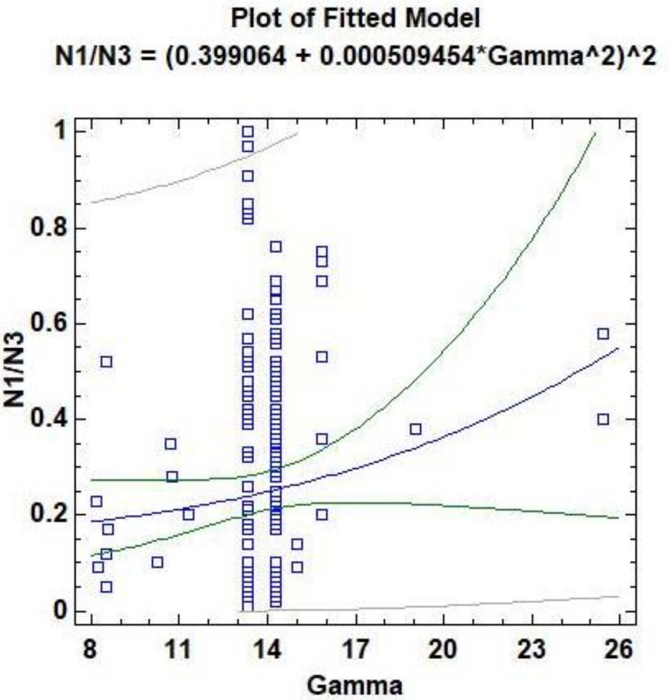
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	0.153919	1	0.153919	2.57	0.1108
Residual	8.66864	145	0.0597837		
Total (Corr.)	8.82255	146			

Correlation Coefficient = 0.132084
R-squared = 1.74461 percent
R-squared (adjusted for d.f.) = 1.06699 percent
Standard Error of Est. = 0.244507
Mean absolute error = 0.210825
Durbin-Watson statistic = 0.784855 (P=0.0000)
Lag 1 residual autocorrelation = 0.606326

The equation of the fitted model is:

N1/N3 = (0.399064 + 0.000509454*Gamma^2) ^2



Simple regression – N1 vs N1/N3

Dependent variable: N1/N3
Independent variable: N1
Square root-Y logarithmic-X model: Y = (a + b*ln(X)) ^2

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	-0.590974	0.113407	-5.21111	0.0000
Slope	0.090345	0.009307	9.7072	0.0000

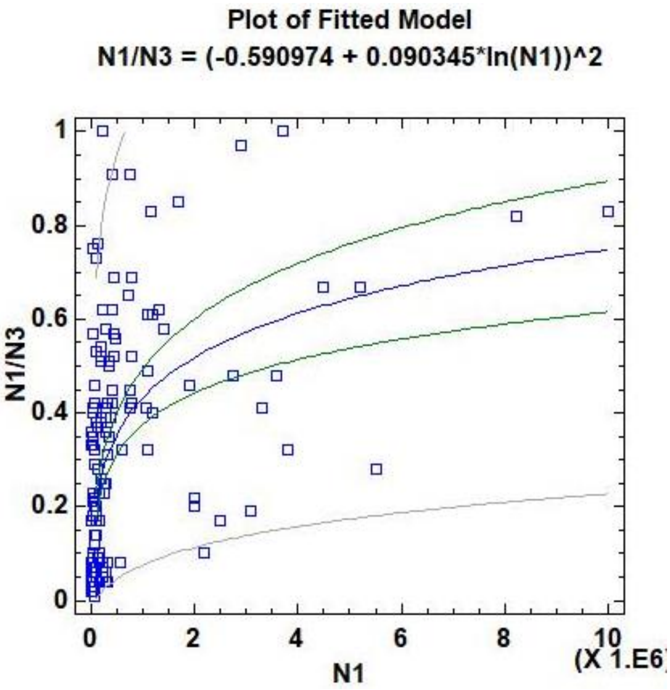
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	3.4751	1	3.4751	94.23	0.0000
Residual	5.34746	145	0.036879		
Total (Corr.)	8.82255	146			

Correlation Coefficient = 0.627605
R-squared = 39.3888 percent
R-squared (adjusted for d.f.) = 38.9708 percent
Standard Error of Est. = 0.192039
Mean absolute error = 0.156115
Durbin-Watson statistic = 1.12443 (P=0.0000)
Lag 1 residual autocorrelation = 0.437224

The equation of the fitted model is:

N1/N3 = (-0.590974 + 0.090345*ln(N1))^2



Simple regression – N3 vs N1/N3

Dependent variable: N1/N3
Independent variable: N3
Double reciprocal model: Y = 1/ (a + b/X)

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	12.0975	1.3926	8.687	0.0000
Slope	-519779.	311147.	-1.67053	0.0970

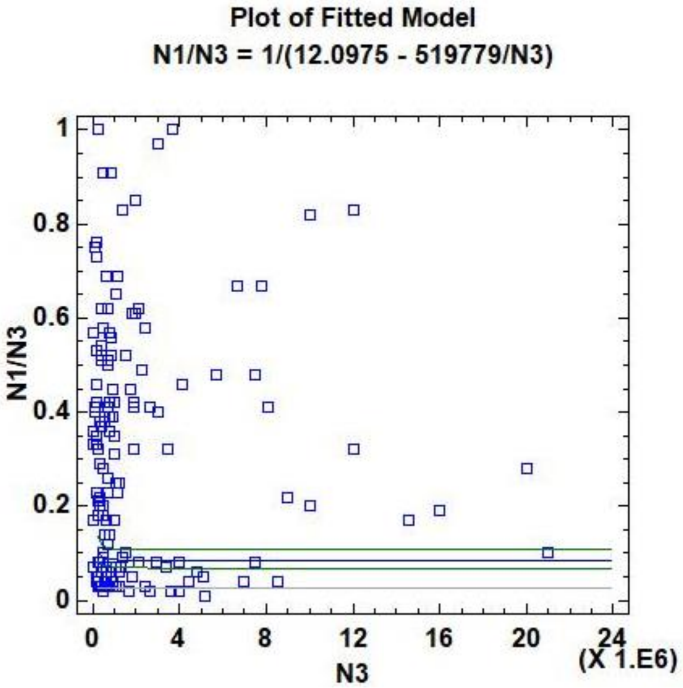
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	568.562	1	568.562	2.79	0.0970
Residual	29541.9	145	203.737		
Total (Corr.)	30110.5	146			

Correlation Coefficient = -0.137414
R-squared = 1.88825 percent
R-squared (adjusted for d.f.) = 1.21162 percent
Standard Error of Est. = 14.2737
Mean absolute error = 10.2537
Durbin-Watson statistic = 1.01062 (P=0.0000)
Lag 1 residual autocorrelation = 0.493514

The equation of the fitted model is:

N1/N3 = 1/(12.0975 - 519779/N3)



Simple regression – Re vs N1/N3

Dependent variable: N1/N3
Independent variable: Re
Reciprocal-Y logarithmic-X model: Y = 1/ (a + b*ln(X))

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	14.491	1.74053	8.3256	0.0000
Slope	3.20698	1.14627	2.79775	0.0058

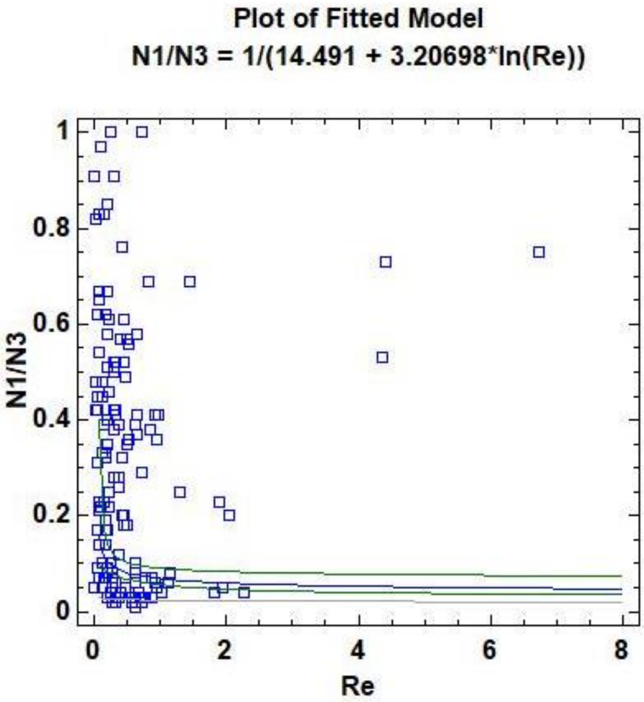
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	1542.17	1	1542.17	7.83	0.0058
Residual	28568.3	145	197.023		
Total (Corr.)	30110.5	146			

Correlation Coefficient = 0.226312
R-squared = 5.12171 percent
R-squared (adjusted for d.f.) = 4.46738 percent
Standard Error of Est. = 14.0365
Mean absolute error = 9.80173
Durbin-Watson statistic = 1.12881 (P=0.0000)
Lag 1 residual autocorrelation = 0.435304

The equation of the fitted model is

N1/N3 = 1/ (14.491 + 3.20698*ln (Re))



Simple regression – HSS vs N1/N3

Dependent variable: N1/N3
Independent variable: HSS
Logarithmic-Y squared-X: Y = exp (a + b*X^2)

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	-1.82129	0.132241	-13.7724	0.0000
Slope	0.00000174245	0.00000118826	1.46639	0.1447

NOTE: intercept = ln(a)

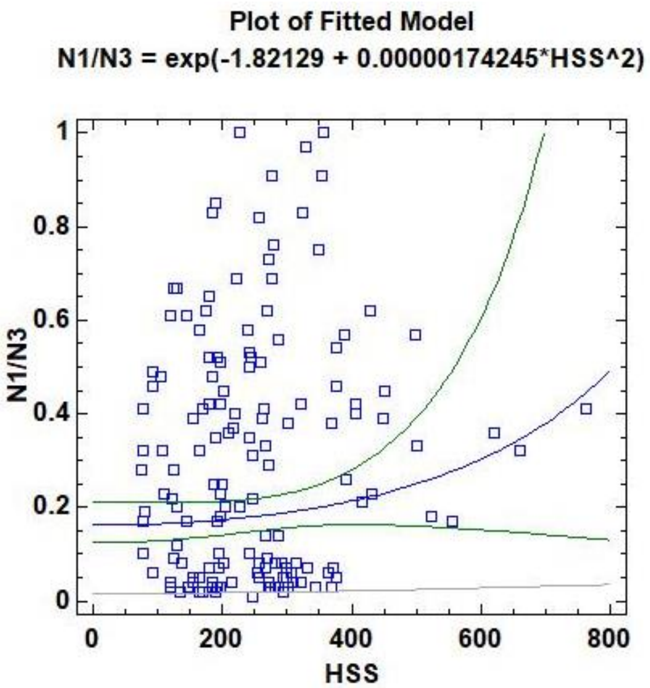
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	2.88144	1	2.88144	2.15	0.1447
Residual	194.304	145	1.34003		
Total (Corr.)	197.185	146			

Correlation Coefficient = 0.120884
R-squared = 1.46129 percent
R-squared (adjusted for d.f.) = 0.78171 percent
Standard Error of Est. = 1.1576
Mean absolute error = 1.00332
Durbin-Watson statistic = 0.69136 (P=0.0000)
Lag 1 residual autocorrelation = 0.653825

The equation of the fitted model is:

N1/N3 = exp (-1.82129 + 0.00000174245*HSS^2)



Simple regression – HSS Thickness Corrected vs N1/N3

Dependent variable: N1/N3
Independent variable: HSS Thickness Corrected
Reciprocal-Y squared-X: Y = 1/ (a + b*X^2)

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	12.5714	1.65007	7.61873	0.0000
Slope	-0.0000219591	0.0000147599	-1.48775	0.1390

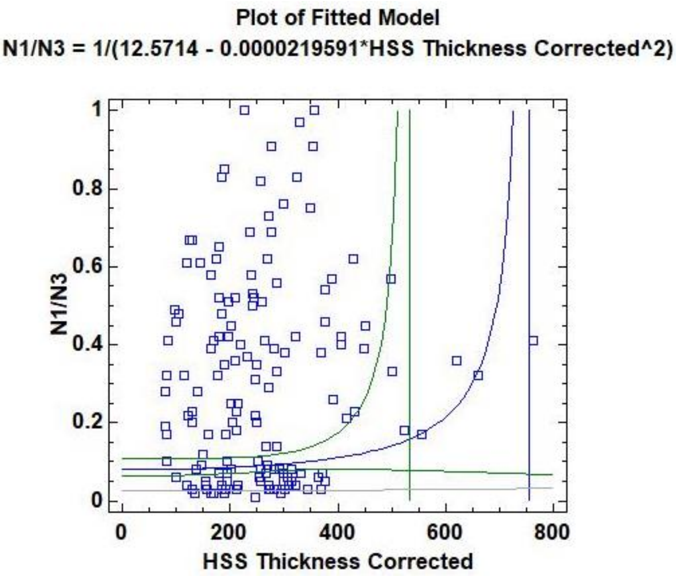
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	452.721	1	452.721	2.21	0.1390
Residual	29657.8	145	204.536		
Total (Corr.)	30110.5	146			

Correlation Coefficient = -0.122619
R-squared = 1.50353 percent
R-squared (adjusted for d.f.) = 0.824247 percent
Standard Error of Est. = 14.3016
Mean absolute error = 10.2356
Durbin-Watson statistic = 1.01185 (P=0.0000)
Lag 1 residual autocorrelation = 0.492813

The equation of the fitted model is:

N1/N3 = 1/ (12.5714 - 0.0000219591*HSS Thickness Corrected^2)



3.9. (N3-N1)/N3

It's considered the time that takes from the first sign of the crack initiation until it goes through the plate thickness.

<u>Simple regression – Thickness vs (N3/N1)/N3</u>

Dependent variable: (N3-N1)/N3
Independent variable: Thickness
Square root-Y logarithmic-X model: Y = (a + b*ln(X)) ^2

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	0.674287	0.0633085	10.6508	0.0000
Slope	0.051254	0.0234035	2.19001	0.0301

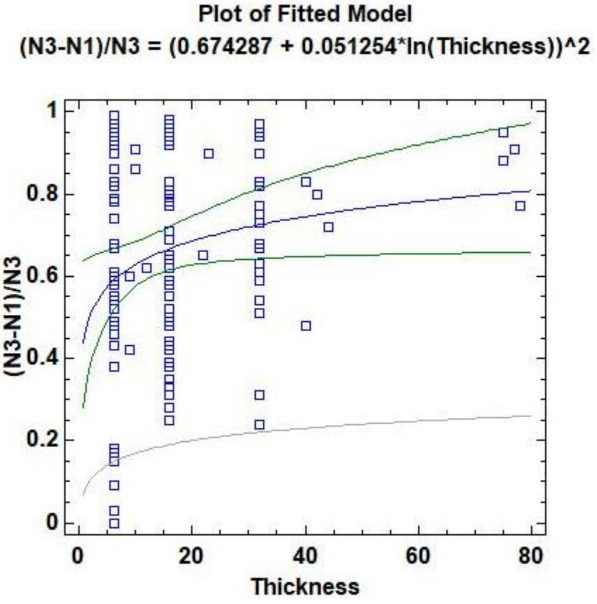
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	0.176489	1	0.176489	4.80	0.0301
Residual	5.33569	145	0.0367979		
Total (Corr.)	5.51218	146			

Correlation Coefficient = 0.178936
R-squared = 3.20179 percent
R-squared (adjusted for d.f.) = 2.53422 percent
Standard Error of Est. = 0.191828
Mean absolute error = 0.144264
Durbin-Watson statistic = 1.10297 (P=0.0000)
Lag 1 residual autocorrelation = 0.44677

The equation of the fitted model is

(N3-N1)/N3 = (0.674287 + 0.051254*ln (Thickness)) ^2



Simple regression – β vs (N3/N1)/N3

Dependent variable: (N3-N1)/N3
Independent variable: Beta
Squared-Y reciprocal-X model: Y = sqrt (a + b/X)

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	0.416647	0.066388	6.27594	0.0000
Slope	0.069493	0.0333457	2.08402	0.0389

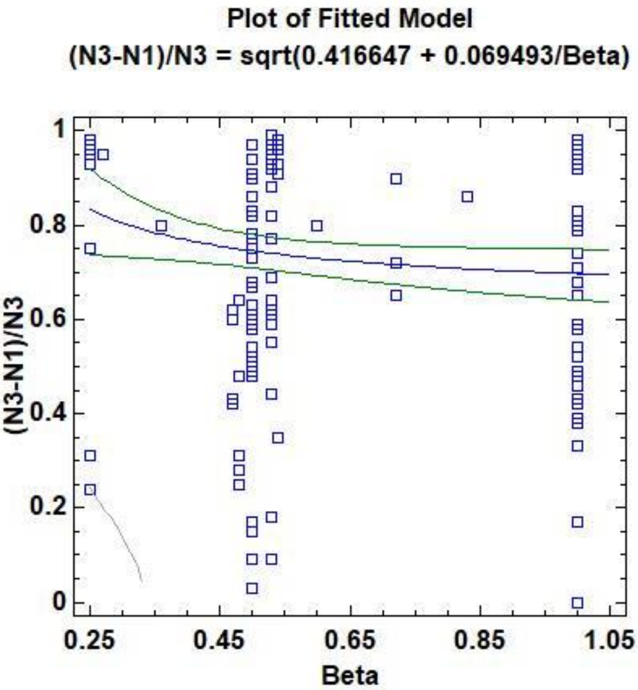
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	0.425157	1	0.425157	4.34	0.0389
Residual	14.1943	145	0.0978918		
Total (Corr.)	14.6195	146			

Correlation Coefficient = 0.170533
R-squared = 2.90815 percent
R-squared (adjusted for d.f.) = 2.23856 percent
Standard Error of Est. = 0.312877
Mean absolute error = 0.276343
Durbin-Watson statistic = 0.7818 (P=0.0000)
Lag 1 residual autocorrelation = 0.607012

The equation of the fitted model is

(N3-N1)/N3 = sqrt (0.416647 + 0.069493/Beta)



<u>Simple regression – τ vs (N3/N1)/N3</u>

Dependent variable: (N3-N1)/N3
Independent variable: Tau
Square root-Y reciprocal-X model: Y = (a + b/X) ^2

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	0.782977	0.0440128	17.7898	0.0000
Slope	0.0147301	0.0236182	0.623677	0.5338

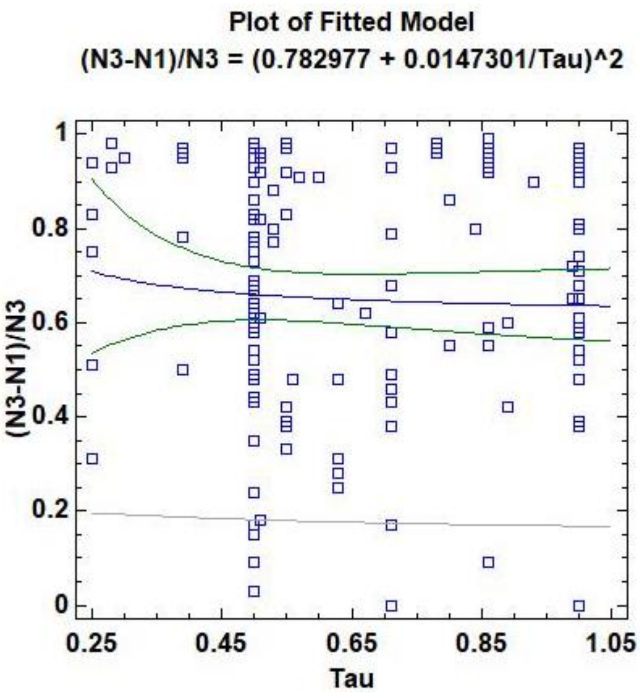
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	0.0147473	1	0.0147473	0.39	0.5338
Residual	5.49743	145	0.0379133		
Total (Corr.)	5.51218	146			

Correlation Coefficient = 0.0517243
R-squared = 0.26754 percent
R-squared (adjusted for d.f.) = -0.42027 percent
Standard Error of Est. = 0.194713
Mean absolute error = 0.14572
Durbin-Watson statistic = 1.08837 (P=0.0000)
Lag 1 residual autocorrelation = 0.453964

The equation of the fitted model is

(N3-N1)/N3 = (0.782977 + 0.0147301/Tau) ^2



Simple regression – γ vs (N3/N1)/N3

Dependent variable: (N3-N1)/N3
Independent variable: Gamma
Squared-Y model: Y = sqrt (a + b*X)

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	0.881302	0.185331	4.75528	0.0000
Slope	-0.024301	0.013226	-1.83736	0.0682

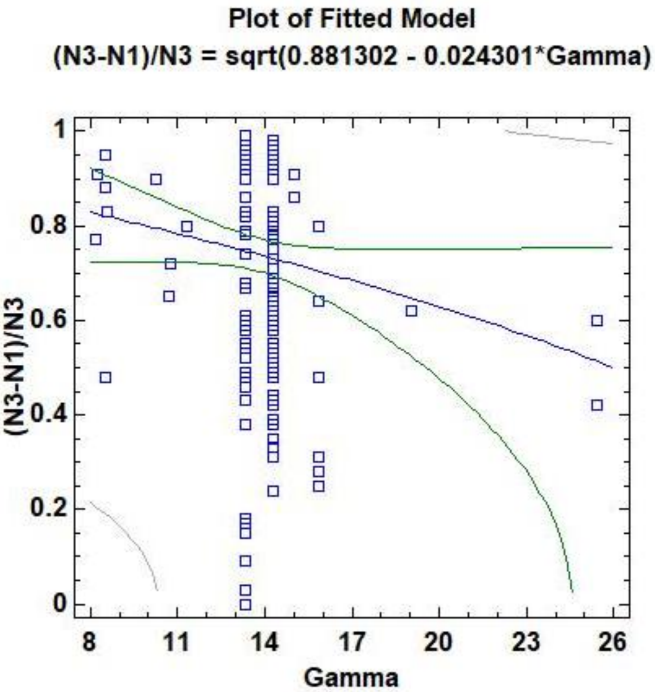
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	0.332627	1	0.332627	3.38	0.0682
Residual	14.2868	145	0.0985299		
Total (Corr.)	14.6195	146			

Correlation Coefficient = -0.150839
R-squared = 2.27524 percent
R-squared (adjusted for d.f.) = 1.60127 percent
Standard Error of Est. = 0.313895
Mean absolute error = 0.276686
Durbin-Watson statistic = 0.810796 (P=0.0000)
Lag 1 residual autocorrelation = 0.592588

The equation of the fitted model is

(N3-N1)/N3 = sqrt (0.881302 - 0.024301*Gamma)



Simple regression – N1 vs (N3/N1)/N3

Dependent variable: (N3-N1)/N3
Independent variable: N1
Squared-Y logarithmic-X model: Y = sqrt (a + b*ln(X))

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	1.93207	0.147008	13.1426	0.0000
Slope	-0.115033	0.0120646	-9.53477	0.0000

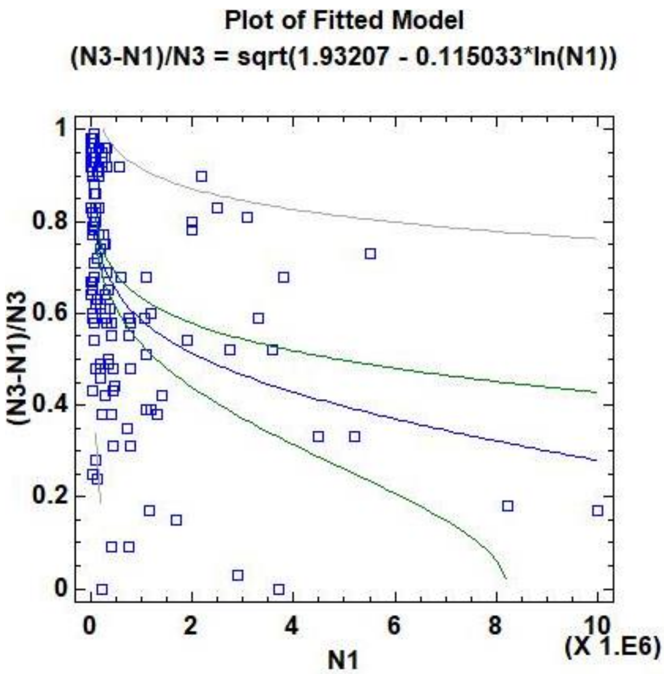
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	5.63381	1	5.63381	90.91	0.0000
Residual	8.98566	145	0.0619701		
Total (Corr.)	14.6195	146			

Correlation Coefficient = -0.620776
R-squared = 38.5363 percent
R-squared (adjusted for d.f.) = 38.1125 percent
Standard Error of Est. = 0.248938
Mean absolute error = 0.204768
Durbin-Watson statistic = 1.15663 (P=0.0000)
Lag 1 residual autocorrelation = 0.420571

The equation of the fitted model is

(N3-N1)/N3 = sqrt (1.93207 - 0.115033*ln(N1))



Simple regression – N3 vs (N3/N1)/N3

Dependent variable: (N3-N1)/N3
Independent variable: N3
Squared-Y reciprocal-X model: Y = sqrt (a + b/X)

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	0.561515	0.030861	18.1949	0.0000
Slope	-7275.55	6895.27	-1.05515	0.2931

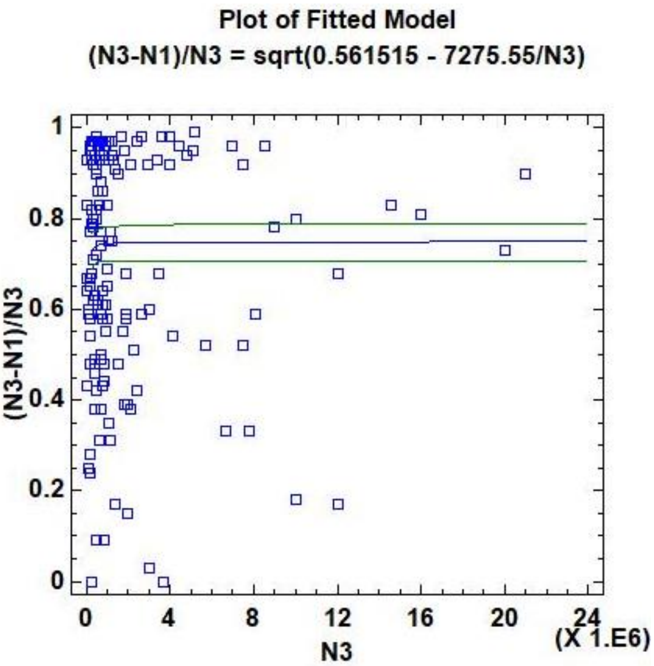
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	0.111396	1	0.111396	1.11	0.2931
Residual	14.5081	145	0.100056		
Total (Corr.)	14.6195	146			

Correlation Coefficient = -0.087291
R-squared = 0.761973 percent
R-squared (adjusted for d.f.) = 0.0775723 percent
Standard Error of Est. = 0.316316
Mean absolute error = 0.280778
Durbin-Watson statistic = 0.793902 (P=0.0000)
Lag 1 residual autocorrelation = 0.601744

The equation of the fitted model is

(N3-N1)/N3 = sqrt (0.561515 - 7275.55/N3)



Simple regression – Re vs (N3/N1)/N3

Dependent variable: (N3-N1)/N3
Independent variable: Re
Reciprocal-X model: Y = a + b/X

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	0.728769	0.025858	28.1835	0.0000
Slope	-0.00711306	0.00287177	-2.47689	0.0144

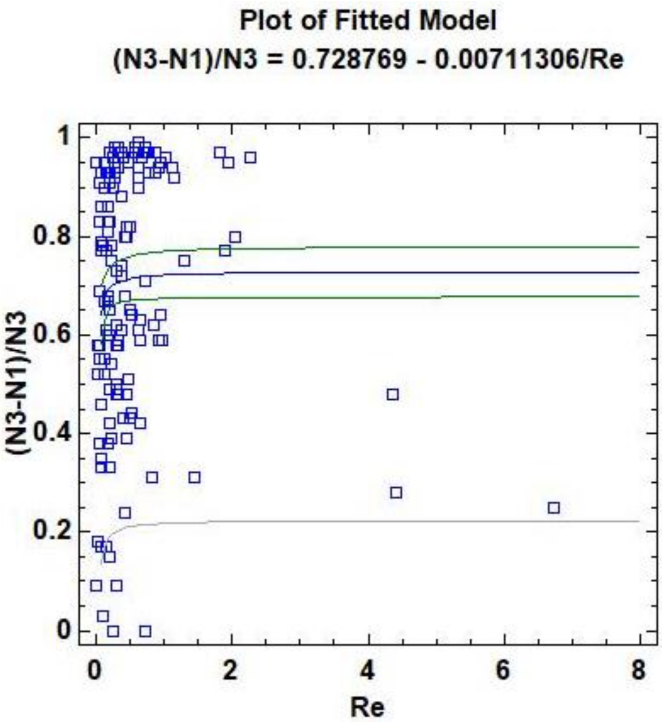
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	0.395794	1	0.395794	6.13	0.0144
Residual	9.35459	145	0.0645144		
Total (Corr.)	9.75038	146			

Correlation Coefficient = -0.201476
R-squared = 4.05926 percent
R-squared (adjusted for d.f.) = 3.3976 percent
Standard Error of Est. = 0.253997
Mean absolute error = 0.212129
Durbin-Watson statistic = 1.06351 (P=0.0000)
Lag 1 residual autocorrelation = 0.46546

The equation of the fitted model is

(N3-N1)/N3 = 0.728769 - 0.00711306/Re



Simple regression – HSS vs (N3/N1)/N3

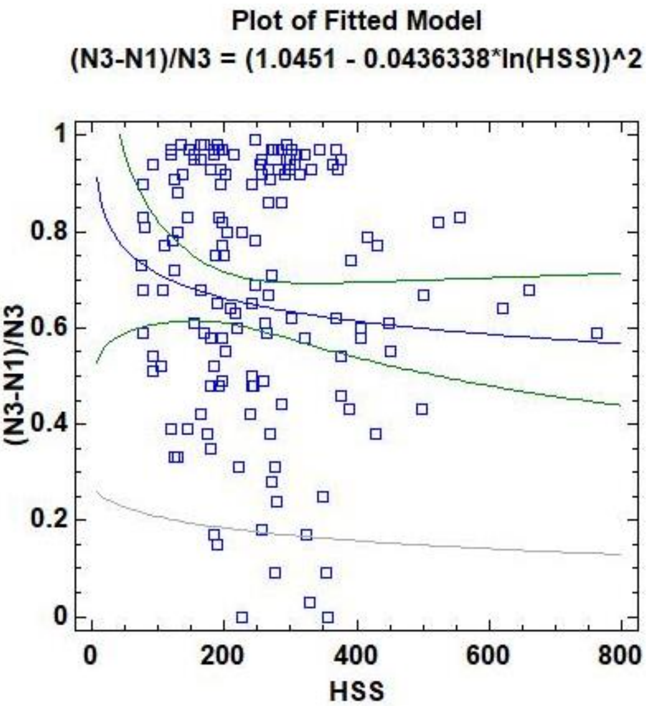
Dependent variable: (N3-N1)/N3
Independent variable: HSS
Square root-Y logarithmic-X model: Y = (a + b*ln(X)) ^2

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	1.0451	0.186491	5.60403	0.0000
Slope	-0.0436338	0.0342703	-1.27322	0.2050

Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	0.0609447	1	0.0609447	1.62	0.2050
Residual	5.45124	145	0.0375947		
Total (Corr.)	5.51218	146			



Correlation Coefficient = -0.105149
R-squared = 1.10564 percent
R-squared (adjusted for d.f.) = 0.423607 percent
Standard Error of Est. = 0.193894
Mean absolute error = 0.145374
Durbin-Watson statistic = 1.09784 (P=0.0000)
Lag 1 residual autocorrelation = 0.449415

The equation of the fitted model is

(N3-N1)/N3 = (1.0451 - 0.0436338*ln (HSS)) ^2

Simple regression – HSS Thickness Corrected vs (N3/N1)/N3

Dependent variable: (N3-N1)/N3
Independent variable: HSS Thickness Corrected
Double-squared: Y = sqrt (a + b*X^2)

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	0.574949	0.0364518	15.7729	0.0000
Slope	-3.94363E-7	3.26063E-7	-1.20947	0.2285

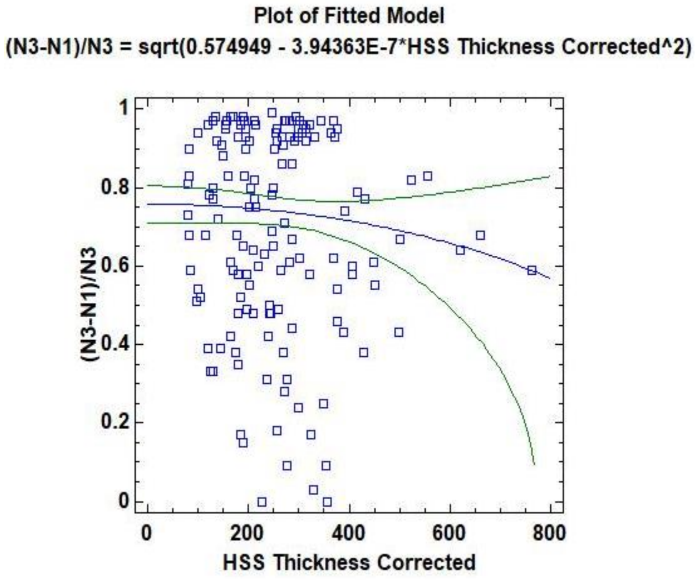
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	0.146014	1	0.146014	1.46	0.2285
Residual	14.4735	145	0.0998169		
Total (Corr.)	14.6195	146			

Correlation Coefficient = -0.0999381
R-squared = 0.998762 percent
R-squared (adjusted for d.f.) = 0.315995 percent
Standard Error of Est. = 0.315938
Mean absolute error = 0.280085
Durbin-Watson statistic = 0.816651 (P=0.0000)
Lag 1 residual autocorrelation = 0.590311

The equation of the fitted model is

(N3-N1)/N3 = sqrt (0.574949 - 3.94363E-7*HSS Thickness Corrected^2)



3.10. Strength factor Qu

Strength factor for tension forces is based on limiting the resistance to the first crack. [7]

This factor varies on the joint classification and brace type and was calculated as given in table 1 from [6]:

Table 25 Values for Qu

Joint classification	Brace force			
	Axial tension	Axial compression	In-plane bending	Out-of-plane bending
K	$(1{,}9+19\beta)Q_\beta^{0{,}5}Q_g$	$(1{,}9+19\beta)Q_\beta^{0{,}5}Q_g$	$4{,}5\ \beta\ \gamma^{0{,}5}$	$3{,}2\ \gamma^{(0{,}5\ \beta^2)}$
Y	$30\ \beta$	$(1{,}9+19\beta)Q_\beta^{0{,}5}$	$4{,}5\ \beta\ \gamma^{0{,}5}$	$3{,}2\ \gamma^{(0{,}5\ \beta^2)}$
X	$23\ \beta$ for $\beta \leqslant 0{,}9$ $20{,}7 + (\beta - 0{,}9)\ (17\ \gamma - 220)$ for $\beta > 0{,}9$	$[2{,}8+(12+0{,}1\gamma)\beta]Q_\beta$	$4{,}5\ \beta\ \gamma^{0{,}5}$	$3{,}2\ \gamma^{(0{,}5\ \beta^2)}$
Where Q_β and Q_g are given by Equations (14.3-5) to (14.3-8).				

To obtain the strength factor on the different joints two factors need to be calculated, Q_β which is a geometrical factor, and Qg which is a gap factor. But due to lack of data from the data collected the gap factor can't be calculated so it is proposed to have a value of 1.

The geometrical factor is defined by:

$$Q_\beta = \frac{0.3}{\beta(1-0.833\beta)} \qquad \text{For } \beta > 0.6 \qquad (19)$$

$$Q_\beta = 1 \qquad \text{For } \beta \leq 0.6 \qquad (20)$$

Specimens considered for the strength factor were only joints with a weld profile of as-welded, a load case with no compressive end chord, and only joints from the following references: Damilano 1981, Gibstein 1981, UKORSP I, UKORSP II, and Zhang and Wintle.

A total of 147 specimens were selected which they met the criteria and from those, the analysis of regression was carried out.

Simple regression – Re vs Qu

Dependent variable: Re
Independent variable: Qu
Logarithmic-Y squared-X: Y = exp (a + b*X^2)

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	-0.89499	0.105063	-8.51862	0.0000
Slope	-0.0010065	0.000284629	-3.53619	0.0005

NOTE: intercept = ln(a)

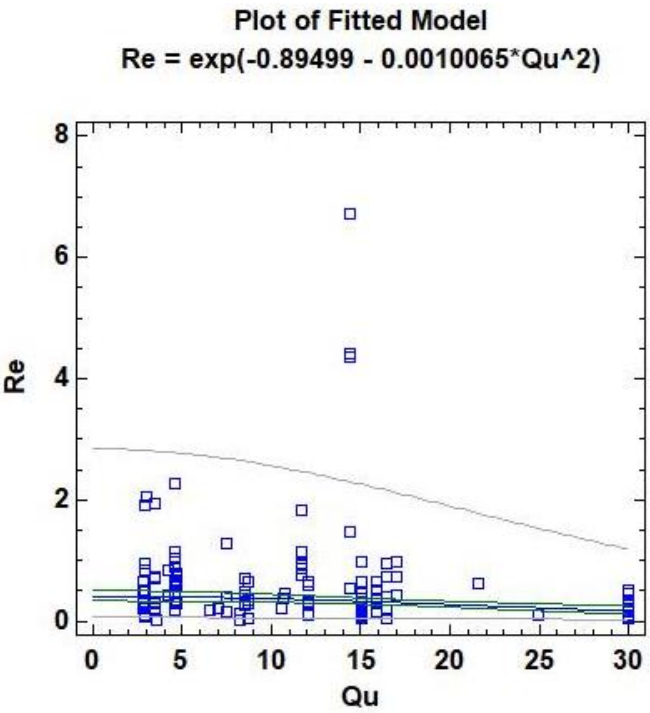
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	11.9046	1	11.9046	12.50	0.0005
Residual	138.043	145	0.952019		
Total (Corr.)	149.947	146			

Correlation Coefficient = -0.281766
R-squared = 7.93921 percent
R-squared (adjusted for d.f.) = 7.30431 percent
Standard Error of Est. = 0.975715
Mean absolute error = 0.743823
Durbin-Watson statistic = 1.80466 (P=0.1188)
Lag 1 residual autocorrelation = 0.0927817

The equation of the fitted model is:

Re = exp (-0.89499 - 0.0010065*Qu^2)



Simple regression – N1/N3 vs Qu

Dependent variable: N1/N3
Independent variable: Qu
Logarithmic-Y square root-X model: Y = exp (a + b*sqrt(X))

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	-3.18021	0.264901	-12.0053	0.0000
Slope	0.439267	0.0736919	5.96086	0.0000

NOTE: intercept = ln(a)

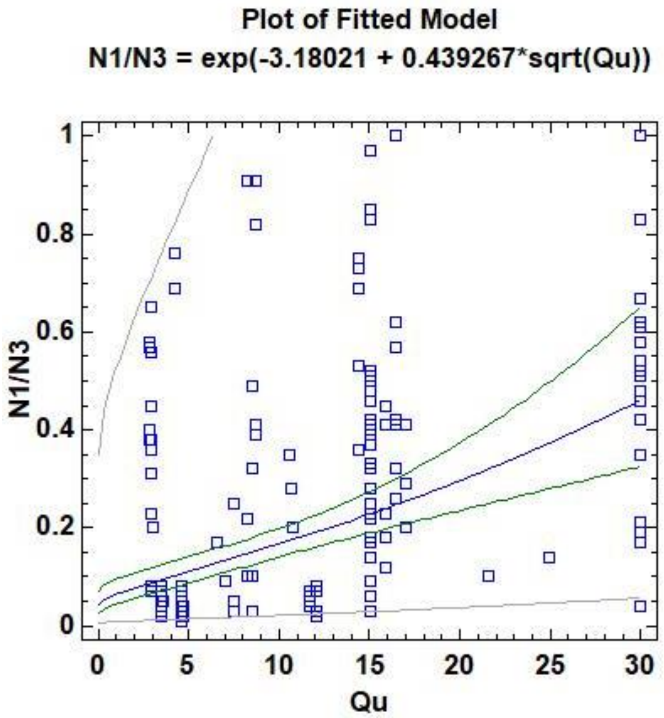
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	38.8096	1	38.8096	35.53	0.0000
Residual	158.376	145	1.09225		
Total (Corr.)	197.185	146			

Correlation Coefficient = 0.443641
R-squared = 19.6818 percent
R-squared (adjusted for d.f.) = 19.1279 percent
Standard Error of Est. = 1.04511
Mean absolute error = 0.862372
Durbin-Watson statistic = 0.939493 (P=0.0000)
Lag 1 residual autocorrelation = 0.527229

The equation of the fitted model is:

N1/N3 = exp (-3.18021 + 0.439267*sqrt (Qu))



Simple regression – (N3-N1)/N3 vs Qu

Dependent variable: (N3-N1)/N3
Independent variable: Qu
Squared-Y model: Y = sqrt (a + b*X)

Coefficients

	Least Squares	*Standard*	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
Intercept	0.749289	0.0436535	17.1645	0.0000
Slope	-0.0158691	0.00283383	-5.59988	0.0000

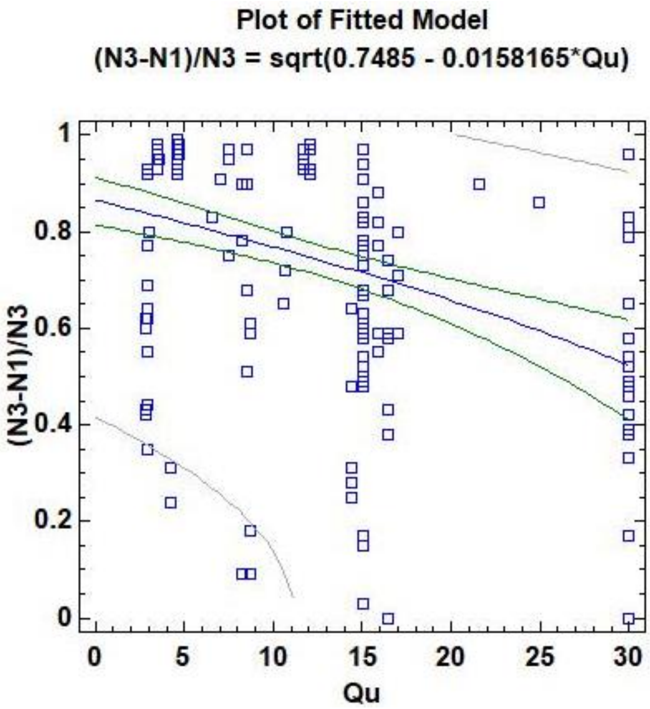
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	2.6032	1	2.6032	31.36	0.0000
Residual	12.037	145	0.0830139		
Total (Corr.)	14.6402	146			

Correlation Coefficient = -0.421677
R-squared = 17.7812 percent
R-squared (adjusted for d.f.) = 17.2141 percent
Standard Error of Est. = 0.288121
Mean absolute error = 0.245752
Durbin-Watson statistic = 1.03539 (P=0.0000)
Lag 1 residual autocorrelation = 0.475649

The equation of the fitted model is:

(N3-N1)/N3 = sqrt (0.7485 - 0.0158165*Qu)



Multiple regression – Re

Dependent variable: Re
Independent variables: Thickness, Beta, Tau, Gamma, N1, N3, HSS, HSS Thickness Corrected, Qu, N1/N3, (N3-N1)/N3

		Standard	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
CONSTANT	-170.526	33.2817	-5.12372	0.0000
Thickness	0.0114814	0.0097486	1.17775	0.2410
Beta	-0.350381	0.451027	-0.776852	0.4386
Tau	0.391124	0.354432	1.10352	0.2718
Gamma	0.0242532	0.0352439	0.688152	0.4925
N1	-1.03069E-7	7.54913E-8	-1.36531	0.1744
N3	-1.35002E-8	2.8675E-8	-0.470799	0.6385
HSS	0.0341219	0.0203274	1.67862	0.0955
HSS Thickness Corrected	-0.0339851	0.0202246	-1.68038	0.0952
Qu	-0.0109192	0.0113379	-0.963072	0.3372
N1/N3	171.142	33.2789	5.14264	0.0000
(N3-N1)/N3	170.585	33.285	5.12497	0.0000

Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	24.2765	11	2.20695	4.28	0.0000
Residual	69.557	135	0.515237		
Total (Corr.)	93.8335	146			

R-squared = 25.8719 percent
R-squared (adjusted for d.f.) = 19.8318 percent
Standard Error of Est. = 0.7178
Mean absolute error = 0.382435
Durbin-Watson statistic = 1.97073 (P=0.4299)
Lag 1 residual autocorrelation = 0.0133239

The equation of the fitted model is

Re = -170.526 + 0.0114814*Thickness - 0.350381*Beta + 0.391124*Tau + 0.0242532*Gamma - 1.03069E-7*N1 - 1.35002E-8*N3 + 0.0341219*HSS - 0.0339851*HSS Thickness Corrected - 0.0109192*Qu + 171.142*N1/N3 + 170.585*(N3-N1)/N3

4. Discussion

Log $\bar{a}$ variation compare to the established in the codes, being almost similar but with certain variation dependent on the used database. The significant difference is in the standard deviation where the OTH 92 390 [2] has 0.23 while the study shows an average of 0.5 more than double from the report.

Data in the plotted S-N curves fit well, follows the curves, and are inside their range except for the N1<1E7 data from the full database which there the data seems flat and doesn't show any relation to the curve.

For the OTH 92 390, the S-N curve for the T design curve for joints with a thickness equal to 32 mm, presents a difference in which maybe is due to the use from the basic design formula to the use of the mean curve adjusted to the standard deviation.

The more favorable distributions in where Re fits are the lognormal and Weibull distributions, but as looking closely the tails of the plots can distinguish the best fit for all is the lognormal distribution.

Normal requirements in a statistical test are not reached in many of these analyses. However, for fatigue design we accept much lower correlation and R squared factors than statisticians normally accept.

Besides that, the parameters that showed the major correlation to Re, N1/N3, and (N3-N1)/N3 were the strength factor (Qu) and the stage of failure N1.

From the start of the analysis of the data in the Zhang and Wintle for Re perceived that the standardized skewness and standardized kurtosis values are not within the range expected for the data to be a normal distribution and as it was plotted this corroborate.

For the X-joints in Zhang and Wintle notice that the Re value under axial loading increases but under IPB it decreases.

The four Re values more that we were able to calculate from Zhangs and Wintle are specimen no. FA*, FB, FC, and 216. All specimens are tested in Air with constant amplitude.

5. Conclusion

There are no parameters establish on the codes for S-N curves at N1, probably due to lack of tests, so the comparing in this work for the parameters obtain at this points were also compared to the N3 parameters which are in the codes.

A lognormal probability distribution is the fit best for the Re data from the full database and the "Zhang and Wintle" report.

On the regression analysis for Re there is a statistically significant relationship at the 95.0% confidence level between Re and the parameters of thickness, γ, N1, N3, HSS, (N1/N3), (N3-N1)/N3 and Qu.

As for Re with β, τ, HSS thickness corrected, there is not a statistically significant relationship between them.

Even if the correlation coefficient indicates a weak relationship between variables and Re, there was a significant accomplishment for fatigue design.

Unfortunately, few samples from specimens on seawater free corrosion and seawater with cathodic protection for better analysis and correlation in fatigue design.

6. References

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7. Appendix 1: Collected test results for database

Air data environment

Table Ap1-1.1

Tested by Kurobane 1973, loading type: AX; constant amplitude loading, weld preparation: As welded: R = -1

Joint Type	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
NK - Joint	140.8	3.89	76.2	3.2	0.54	0.82	18.10	-	4.3E+06	-	5.2E+06	-	-
NK - Joint	140.8	3.89	76.5	3.2	0.54	0.82	18.10	-	1.2E+05	-	3.0E+05	-	-
NK - Joint	140.8	3.9	60.7	3.2	0.43	0.82	18.05	-	2.0E+06	-	2.4E+06	-	-
NK - Joint	140.3	3.91	60.9	3.2	0.43	0.82	17.94	-	2.2E+05	-	4.8E+05	-	-
NK - Joint	140.4	3.91	60.6	3.2	0.43	0.82	17.95	-	2.8E+05	-	5.0E+05	-	-
NK - Joint	140.3	3.92	89.5	3.2	0.64	0.82	17.90	-	3.5E+05	-	9.2E+05	-	-
NK - Joint	140.4	3.92	89.6	3.2	0.64	0.82	17.91	-	4.5E+04	-	1.3E+05	-	-
OK - Joint	140.6	3.92	61	3.2	0.43	0.82	17.93	-	1.5E+06	-	3.0E+06	-	-
NK - Joint	140.5	3.93	60.9	3.2	0.43	0.81	17.88	-	5.0E+04	-	5.6E+04	-	-
NK - Joint	140.7	3.94	76.3	3.2	0.54	0.81	17.86	-	5.6E+04	-	7.9E+04	-	-
NK - Joint	140.7	3.94	60.8	3.2	0.43	0.81	17.86	-	7.0E+06	-	7.3E+06	-	-
OK - Joint	140.3	3.94	60.8	3.2	0.43	0.81	17.80	-	1.0E+05	-	1.3E+05	-	-
OK - Joint	140.5	3.94	60.9	3.2	0.43	0.81	17.83	-	1.7E+05	-	1.8E+05	-	-
NK - Joint	140	3.95	89.8	3.2	0.64	0.81	17.72	-	1.4E+06	-	1.9E+06	-	-
NK - Joint	140.4	3.97	60.9	3.2	0.43	0.81	17.68	-	7.1E+04	-	1.1E+05	-	-
NK - Joint	140	4.2	60.9	3.2	0.44	0.76	16.67	-	1.0E+04	-	1.8E+05	-	-
OK - Joint	140	4.21	76.8	3.2	0.55	0.76	16.63	-	5.1E+05	-	1.0E+06	-	-
OK - Joint	140	4.23	76.5	3.2	0.55	0.76	16.55	-	1.2E+06	-	5.1E+06	-	-
OK - Joint	140	4.25	76.6	3.2	0.55	0.75	16.47	-	7.8E+04	-	1.4E+05	-	-
NK - Joint	139.9	4.26	61	3.2	0.44	0.75	16.42	-	1.9E+04	-	2.5E+04	-	-

(Continued from table A1-1.1)

Joint Type	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
NK - Joint	139.9	4.26	60.8	3.2	0.43	0.75	16.42	-	3.0E+03	-	5.8E+03	-	-
OK - Joint	140	4.26	60.8	3.2	0.43	0.75	16.43	-	9.5E+03	-	1.6E+04	-	-
NK - Joint	139.8	4.36	89.4	3.2	0.64	0.73	16.03	-	2.9E+04	-	5.3E+04	-	-
NK - Joint	139.9	4.37	76.5	3.2	0.55	0.73	16.01	-	3.9E+03	-	1.1E+04	-	-
OK - Joint	140	4.38	76.5	3.2	0.55	0.73	15.98	-	1.5E+04	-	2.4E+04	-	-
NK - Joint	139.8	4.42	60.8	3.2	0.43	0.72	15.81	-	9.7E+04	-	1.3E+05	-	-
NK - Joint	139.8	4.42	60.9	3.2	0.44	0.72	15.81	-	5.5E+05	-	9.7E+05	-	-
NK - Joint	139.8	4.42	60.6	3.2	0.43	0.72	15.81	-	8.0E+05	-	1.1E+06	-	-

Table Ap1-1.2

Weld	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
As welded	168	6	89	5	0.53	0.83	14.00	-	6.0E+04	2.0E+06	2.4E+06	0.20	249
As welded	168	6	89	3	0.53	0.50	14.00	-	9.2E+03	2.5E+05	3.1E+05	0.24	411

Some other information about the data:

1. Tested by TWI
2. Loading type: OPB; Stress ratio R=0; Joint Type: OK
3. Loading Spectrum: Constant Amplitude

Table Ap1-1.3

Weld	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
As welded	168	6.3	168	4.5	1.00	0.71	13.33	-	-	-	2.0E+08	-	191
As welded	168	6.3	168	4.5	1.00	0.71	13.33	1.7E+06	-	-	5.4E+06	-	228
As welded	168	6.3	168	4.5	1.00	0.71	13.33	-	-	-	1.5E+08	-	162
As welded	168	6.3	89.04	5.4	0.53	0.86	13.33	-	-	-	2.0E+07	-	304
As welded	168	6.3	89.04	3.2	0.53	0.51	13.33	-	-	-	2.0E+08	-	210
As welded	168	6.3	89.04	3.2	0.53	0.51	13.33	-	-	-	4.0E+06	-	489
As welded	168	6.3	168	6.3	1.00	1.00	13.33	2.7E+06	5.2E+06	5.7E+06	5.9E+06	0.04	185
As welded	168	6.3	168	6.3	1.00	1.00	13.33	8.0E+05	1.4E+06	1.5E+06	2.0E+06	0.33	245
As welded	168	6.3	168	4.5	1.00	0.71	13.33	2.1E+05	3.5E+05	4.2E+05	5.4E+05	0.31	259
As welded	168	6.3	89.04	5.4	0.53	0.86	13.33	3.2E+04	6.2E+04	7.8E+04	1.3E+05	0.65	763
As welded	168	6.3	89.04	5.4	0.53	0.86	13.33	-	3.8E+05	4.3E+05	7.1E+05	0.67	538
As welded	168	6.3	168	4.5	1.00	0.71	13.33	1.2E+06	1.3E+06	1.4E+06	1.6E+06	0.16	324
As welded	168	6.3	168	4.5	1.00	0.71	13.33	2.2E+05	2.2E+05	2.2E+05	2.8E+05	0.26	357
As welded	168	6.3	168	6.3	1.00	1.00	13.33	7.6E+04	1.5E+05	1.6E+05	2.0E+05	0.22	376
As welded	168	6.3	168	4.5	1.00	0.71	13.33	2.1E+05	2.5E+05	3.9E+05	4.2E+05	0.09	377
As welded	168	6.3	168	4.5	1.00	0.71	13.33	4.6E+04	1.5E+05	2.2E+05	2.4E+05	0.09	417
As welded	168	6.3	89.04	5.4	0.53	0.86	13.33	7.7E+05	1.2E+06	1.7E+06	1.9E+06	0.13	450
As welded	168	6.3	89.04	3.2	0.53	0.51	13.33	4.2E+04	1.8E+05	2.4E+05	3.6E+05	0.51	523

Some other information about the data:

1. Tested by UKOSRP I
2. Loading type: AX; Stress ratio R= -1; Joint Type: T
3. Loading Spectrum: Constant Amplitude

Table Ap1-1.4

Weld	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
As welded	168	6.3	168	6.3	1.00	1.00	13.33	-	-	1.4E+06	2.0E+06	0.43	53.4
As welded	168	6.3	168	6.3	1.00	1.00	13.33	-	2.3E+06	4.1E+06	4.7E+06	0.15	38.2
As welded	168	6.3	168	6.3	1.00	1.00	13.33	-	-	-	2.0E+07	-	27.6
As welded	168	6.3	168	4.5	1.00	0.71	13.33	-	1.1E+06	1.8E+06	2.2E+06	0.22	54
As welded	168	6.3	168	4.5	1.00	0.71	13.33	-	2.6E+06	4.4E+06	4.6E+06	0.05	41.6
As welded	168	6.3	168	4.5	1.00	0.71	13.33	-	9.0E+05	1.9E+06	2.2E+06	0.16	59.67
As welded	168	6.3	89.04	5.4	0.53	0.86	13.33	-	4.0E+05	1.2E+06	1.4E+06	0.17	105
As welded	168	6.3	89.04	5.4	0.53	0.86	13.33	-	2.9E+06	3.4E+06	4.2E+06	0.24	91.5
As welded	168	6.3	89.04	5.4	0.53	0.86	13.33	-	2.0E+05	9.0E+05	1.5E+06	0.67	78.4
As welded	168	6.3	89.04	3.2	0.53	0.51	13.33	-	5.0E+05	2.1E+06	3.2E+06	0.52	84.6
As welded	168	6.3	89.04	3.2	0.53	0.51	13.33	-	-	4.7E+06	7.0E+06	0.49	67.16
As welded	168	6.3	89.04	3.2	0.53	0.51	13.33	-	5.0E+05	1.2E+06	1.8E+06	0.57	79.9

Some other information about the data:

1. Tested by UKOSRP I
2. Loading type: AX; Joint Type: T
3. Loading Spectrum: Variable Amplitude

Table Ap1-1.5

Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	Loading Spectrum	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)	R ratio
168	6.3	168	4.5	CA	1.00	0.71	13.33	1.6E+06	1.6E+06	-	1.9E+06	-	378	-1
168	6.3	168	4.5	CA	1.00	0.71	13.33	6.0E+06	7.9E+06	-	8.6E+06	-	296	-1
168	6.3	168	6.3	CA	1.00	1.00	13.33	1.8E+05	7.2E+05	7.2E+05	1.0E+06	0.39	391	-1
168	6.3	168	6.3	CA	1.00	1.00	13.33	1.1E+06	1.8E+06	2.7E+06	5.2E+06	0.94	265	-1
168	6.3	168	6.3	CA	1.00	1.00	13.33	3.7E+06	3.7E+06	3.7E+06	6.4E+06	0.73	226	-1
168	6.3	89.04	3.2	CA	0.53	0.51	13.33	-	-	-	2.0E+08	-	350	-1
168	6.3	168	4.5	CA	1.00	0.71	13.33	7.9E+05	1.3E+06	1.9E+06	1.9E+06	0.03	407	-1
168	6.3	168	4.5	CA	1.00	0.71	13.33	1.3E+06	1.5E+06	2.1E+06	2.5E+06	0.19	429	-1
168	6.3	168	4.5	CA	1.00	0.71	13.33	7.0E+04	1.4E+05	2.2E+05	2.7E+05	0.19	660	-1
168	6.3	168	4.5	CA	1.00	0.71	13.33	4.4E+05	4.6E+05	7.8E+05	1.1E+06	0.40	497	-1
168	6.3	89.04	5.4	CA	0.53	0.86	13.33	7.5E+05	7.5E+05	8.2E+05	1.1E+06	0.30	355	-1
168	6.3	89.04	5.4	CA	0.53	0.86	13.33	7.7E+05	1.8E+06	1.9E+06	2.5E+06	0.34	265	-1
168	6.3	89.04	5.4	CA	0.53	0.86	13.33	-	3.3E+05	3.6E+05	4.2E+05	0.16	482	-1
168	6.3	89.04	3.2	CA	0.53	0.51	13.33	-	3.1E+05	2.4E+05	3.9E+05	0.66	487	-1
168	6.3	89.04	3.2	CA	0.53	0.51	13.33	2.0E+05	5.0E+05	5.2E+05	8.5E+05	0.64	449	-1
168	6.3	89.04	3.2	CA	0.53	0.51	13.33	8.2E+06	1.0E+07	1.0E+07	1.0E+07	0.04	257	-1
168	6.3	168	6.3	VA	1.00	1.00	13.33	-	4.5E+06	1.2E+07	1.4E+07	0.14	55.7	-
168	6.3	168	6.3	VA	1.00	1.00	13.33	-	2.3E+05	2.8E+05	3.6E+05	0.29	88.3	-
168	6.3	168	6.3	VA	1.00	1.00	13.33	-	2.6E+06	4.8E+06	6.2E+06	0.29	59.9	-

Some other information about the data:

1. Tested by UKOSRP I
2. Loading type: IPB; Joint Type: T
3. Weld preparation: As welded
4. Constant Amplitude = CA; Variable Amplitude = VA

Table Ap1-1.6

Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)	R ratio
168	6.3	168	6.3	1.00	1.00	13.33	1.4E+04	1.2E+05	2.7E+05	5.3E+05	0.96	377	0
168	6.3	168	6.3	1.00	1.00	13.33	2.4E+04	9.7E+04	4.0E+05	8.5E+05	1.13	363.3	0
168	6.3	168	6.3	1.00	1.00	13.33	7.6E+04	5.5E+05	1.2E+06	2.3E+06	0.92	254	0
168	6.3	168	4.5	1.00	0.71	13.33	9.5E+04	3.8E+05	1.3E+06	2.3E+06	0.77	300	0
168	6.3	168	4.5	1.00	0.71	13.33	2.1E+04	6.4E+04	6.0E+05	1.7E+06	1.83	271	0
168	6.3	168	4.5	1.00	0.71	13.33	3.1E+04	1.9E+05	4.7E+05	8.8E+05	0.87	331.8	0
168	6.3	89.04	5.4	0.53	0.86	13.33	1.6E+05	4.0E+05	4.5E+06	9.1E+06	1.04	186	0
168	6.3	89.04	5.4	0.53	0.86	13.33	5.3E+04	6.6E+04	8.6E+05	1.4E+06	0.63	307.7	0
168	6.3	89.04	5.4	0.53	0.86	13.33	7.5E+04	6.6E+05	5.2E+06	8.4E+06	0.62	247.8	0
168	6.3	89.04	3.2	0.53	0.51	13.33	2.2E+04	9.9E+04	5.8E+05	1.9E+06	2.28	308.7	0
168	6.3	89.04	3.2	0.53	0.51	13.33	1.6E+05	3.5E+05	2.1E+06	4.5E+06	1.14	256	0
168	6.3	89.04	3.2	0.53	0.51	13.33	3.2E+05	3.6E+05	4.0E+06	6.5E+06	0.64	292	0
168	6.3	168	4.5	1.00	0.71	13.33	-	-	-	6.1E+07	-	229	-1

Some other information about the data:

1. Tested by UKOSRP I
2. Loading type: OPB; Joint Type: T
3. Weld preparation: As welded
4. Loading Spectrum: Constant Amplitude

Table Ap1-1.7

Load Case	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)	R ratio
AX/CEL	168	6.3	168	6.3	1.00	1.00	13.33	-	-	-	2.0E+08	-	182	-1
IPB/CEL	168	6.3	168	6.3	1.00	1.00	13.33	-	-	-	2.0E+08	-	263	-1
AX/CEL	168	6.3	168	4.5	1.00	0.71	13.33	-	-	-	2.0E+08	-	223	-1
OPB/CEL	168	6.3	168	6.3	1.00	1.00	13.33	2.4E+04	1.1E+05	7.2E+05	2.0E+06	1.78	287.7	0
OPB/CEL	168	6.3	168	6.3	1.00	1.00	13.33	6.6E+04	4.6E+05	1.2E+06	2.0E+06	0.74	319.2	0
OPB/CEL	168	6.3	168	6.3	1.00	1.00	13.33	1.7E+04	8.1E+04	3.1E+05	8.2E+05	1.65	359	0
AX/CEL	168	6.3	168	6.3	1.00	1.00	13.33	6.9E+04	3.2E+05	3.2E+05	3.7E+05	0.15	312	-1
AX/CEL	168	6.3	89.04	3.2	0.53	0.51	13.33	-	-	-	2.0E+08	-	332	-1
IPB/CEL	168	6.3	168	6.3	1.00	1.00	13.33	1.0E+06	1.0E+06	1.5E+06	1.6E+06	0.03	400	-1
IPB/CEL	168	6.3	168	6.3	1.00	1.00	13.33	1.2E+06	1.2E+06	1.5E+06	1.8E+06	0.20	442	-1
IPB/CEL	168	6.3	168	6.3	1.00	1.00	13.33	1.5E+06	1.5E+06	1.5E+06	1.9E+06	0.26	438	-1
AX/CEL	168	6.3	168	6.3	1.00	1.00	13.33	5.0E+05	7.4E+05	8.4E+05	1.2E+06	0.40	255	-1
AX/CEL	168	6.3	168	4.5	1.00	0.71	13.33	2.1E+05	5.0E+05	5.0E+05	5.4E+05	0.09	325	-1
AX/CEL	168	6.3	168	4.5	1.00	0.71	13.33	6.9E+05	9.4E+05	1.0E+06	1.5E+06	0.49	253	-1
AX/CEL	168	6.3	89.04	5.4	0.53	0.86	13.33	-	4.0E+05	4.2E+05	5.1E+05	0.20	549	-1
AX/CEL	168	6.3	89.04	5.4	0.53	0.86	13.33	-	-	9.8E+04	1.3E+05	0.33	912	-1
AX/CEL	168	6.3	89.04	3.2	0.53	0.51	13.33	1.1E+06	2.5E+06	2.7E+06	2.9E+06	0.07	487	-1
AX/CEL	168	6.3	89.04	3.2	0.53	0.51	13.33	-	3.5E+05	4.5E+05	7.8E+05	0.73	493	-1

Some other information about the data:

1. Tested by UKOSRP I
2. Joint Type: T
3. Weld preparation: As welded
4. Loading Spectrum: Constant Amplitude

Table Ap1-1.8

Joint Type	Load Case	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
OK - Joint	AX	168	6.3	89.04	5.4	0.53	0.86	13.33	-	-	-	8.1E+07	-	49.5
OK - Joint	OPB	168	6.3	89.04	5.4	0.53	0.86	13.33	3.9E+04	1.8E+05	1.2E+06	1.6E+06	0.33	275
OK - Joint	OPB	168	6.3	89.04	5.4	0.53	0.86	13.33	2.3E+05	6.2E+05	3.4E+06	4.0E+06	0.18	268
OK - Joint	OPB	168	6.3	89.04	3.2	0.53	0.51	13.33	4.4E+04	2.3E+05	8.7E+05	1.3E+06	0.49	300
OK - Joint	OPB	168	6.3	89.04	3.2	0.53	0.51	13.33	9.3E+04	2.9E+05	1.8E+06	2.3E+06	0.28	256
NK - Joint	AX	168	6.3	89.04	5.4	0.53	0.86	13.33	2.4E+05	3.1E+05	2.9E+06	3.5E+06	0.21	202
NK - Joint	AX	168	6.3	89.04	5.4	0.53	0.86	13.33	-	2.1E+05	-	5.8E+05	-	266
NK - Joint	OPB	168	6.3	89.04	5.4	0.53	0.86	13.33	3.3E+05	3.5E+05	8.5E+06	1.2E+07	0.41	215
NK - Joint	OPB	168	6.3	89.04	5.4	0.53	0.86	13.33	2.5E+04	7.2E+04	9.0E+05	1.7E+06	0.89	302
NKT - Joint	AX	168	6.3	89.04	5.4	0.53	0.86	13.33	-	6.5E+04	2.6E+05	5.3E+05	1.04	297

Some other information about the data:

1. Tested by UKOSRP I
2. Weld preparation: As welded
3. Loading Spectrum: Constant Amplitude
4. Stress Ratio R=0

Table Ap1-1.9

Load Case	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
AX	168	6.3	84	3.2	0.50	0.50	13.33	1.0E+07	-	1.2E+07	1.3E+07	0.08	186
AX	168	6.3	84	3.2	0.50	0.50	13.33	1.7E+06	-	2.0E+06	2.4E+06	0.20	189
IPB	168	6.3	84	3.2	0.50	0.50	13.33	1.5E+05	-	1.5E+06	1.7E+06	0.13	194
AX	168	6.3	84	3.2	0.50	0.50	13.33	1.2E+06	-	3.0E+06	3.6E+06	0.20	219
IPB	168	6.3	84	3.2	0.50	0.50	13.33	7.1E+04	-	3.3E+05	3.7E+05	0.12	247
AX	168	6.3	84	3.2	0.50	0.50	13.33	1.1E+05	-	8.0E+05	9.5E+05	0.19	267
IPB	168	6.3	84	3.2	0.50	0.50	13.33	4.3E+05	-	4.7E+05	4.8E+05	0.02	278
AX	168	6.3	84	3.2	0.50	0.50	13.33	2.9E+06	-	3.0E+06	3.3E+06	0.10	330
AX	168	6.3	84	3.2	0.50	0.50	13.33	2.0E+04	-	6.0E+04	7.0E+04	0.17	501
AX	168	6.3	84	3.2	0.50	0.50	13.33	1.0E+04	-	6.0E+04	7.0E+04	0.17	555

Some other information about the data:

1. Tested by Gibstein 1981
2. Joint type: T; Stress Ratio R=0
3. Weld preparation: As welded
4. Loading Spectrum: Constant Amplitude

Table Ap1-1.10

Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	Loading Spectrum	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
319	9.4	133	7	VA	0.42	0.69	16.97	-	2.4E+05	8.1E+05	9.5E+05	0.17	151
319	9.4	133	7	CA	0.42	0.69	16.97	-	3.5E+04	-	1.3E+05	-	-
319	9.4	133	7	CA	0.42	0.69	16.97	-	1.4E+05	1.6E+05	3.3E+05	1.06	-

Some other information about the data:

1. Tested by Canadian Researchers
2. Loading type: AX
3. Weld preparation: Toe ground

Table Ap1-1.11

Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
457.2	9	216.3	8	0.47	0.89	25.40	5.3E+04	1.0E+05	1.3E+05	1.6E+05	0.21	405
457.2	9	216.3	8	0.47	0.89	25.40	2.8E+05	3.0E+05	4.8E+05	7.9E+05	0.65	239
457.2	12	216.3	8	0.47	0.67	19.05	3.8E+04	3.9E+06	-	6.8E+04	-	397
457.2	12	216.3	8	0.47	0.67	19.05	2.1E+05	3.3E+05	5.6E+05	7.3E+05	0.30	302

Some other information about the data:

1. Tested by UKOSRP II
2. Loading type: AX; Stress Ratio R=0; Joint type: OK
3. Weld preparation: As welded
4. Loading Spectrum: Constant Amplitude

Table Ap1-1.12

Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)	R ratio
300	10	150	6	0.50	0.60	15.00	1.3E+05	2.1E+05	1.4E+06	1.5E+06	0.07	270	0.1
300	10	250	8	0.83	0.80	15.00	7.9E+04	2.0E+06	5.7E+05	6.2E+05	0.09	287	0.1
2000	12.5	711	13	0.36	1.00	80.00	-	-	3.2E+05	7.2E+05	1.25	200	-
2000	12.5	711	13	0.36	1.00	80.00	-	-	9.3E+05	1.3E+06	0.40	160	-

Some other information about the data:

1. Loading type: AX; Joint type: T
2. Weld preparation: As welded
3. Loading Spectrum: Constant Amplitude

Table Ap1-1.13

Chord OD (mm)	γ	N1	N2	N3	N4	Re
324	12.76	-	1.1E+06	1.6E+06	1.7E+06	0.07
324	12.76	-	3.4E+05	5.0E+05	5.9E+05	0.17
324	12.76	-	3.4E+05	1.3E+06	1.4E+06	0.07
324	12.76	-	3.1E+05	4.7E+05	5.2E+05	0.10
324	12.76	-	6.2E+05	6.4E+05	6.7E+05	0.05
324	12.76	-	1.2E+05	1.4E+05	1.5E+05	0.08
324	12.76	-	2.9E+05	3.9E+05	4.0E+05	0.05

Some other information about the data:

1. Tested by TWI
2. Chord Wall Thickness = 12.7 mm
3. Loading Spectrum: Constant Amplitude

Table Ap1-1.15

Joint Type	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	Loading Spectrum	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
T - Joint	457.2	15.9	114.3	6.3	CA	0.25	0.40	14.38	3.5E+05	-	7.0E+05	9.1E+05	0.30	-
T - Joint	457.2	15.9	114.3	6.3	CA	0.25	0.40	14.38	2.0E+06	-	9.0E+06	1.1E+07	0.22	-
X - Joint	457.2	15.9	457.2	8.7	VA	1.00	0.55	14.38	1.7E+06	-	2.0E+06	4.0E+06	1.00	-
X - Joint	457.2	15.9	457.2	8.7	VA	1.00	0.55	14.38	3.2E+06	-	6.5E+06	8.4E+06	0.29	-
X - Joint	457.2	15.9	457.2	8.7	CA	1.00	0.55	14.38	2.6E+06	-	1.0E+07	1.9E+07	0.90	-

Some other information about the data:

1. Tested by Dijkstra 1981
2. Loading type: AX; Stress Ratio R= -1
3. Weld preparation: As welded

Table Ap1-1.16

Joint Type	Chord OD (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)	R ratio
T - Joint	457	457	16	1.00	1.00	14.28	3.1E+06	-	1.6E+07	1.9E+07	0.19	81	-1
T - Joint	457	228.5	8	0.50	0.50	14.28	3.6E+06	-	7.5E+06	8.5E+06	0.13	105	0
T - Joint	457	457	16	1.00	1.00	14.28	1.1E+06	-	1.8E+06	2.2E+06	0.22	119	-1
T - Joint	457	228.5	6.2	0.50	0.39	14.28	2.0E+06	-	9.0E+06	1.1E+07	0.22	123	-1
T - Joint	457	457	8.8	1.00	0.55	14.28	5.2E+06	-	7.8E+06	8.5E+06	0.09	125	-1
T - Joint	457	457	8.8	1.00	0.55	14.28	4.5E+06	-	6.7E+06	8.1E+06	0.21	130	-1
T - Joint	457	457	8.8	1.00	0.55	14.28	1.4E+06	-	2.4E+06	2.9E+06	0.21	164	-1
T - Joint	457	457	16	1.00	1.00	14.28	4.1E+05	-	6.6E+05	7.7E+05	0.17	176	-1
T - Joint	457	228.5	8	0.50	0.50	14.28	4.4E+05	-	8.4E+05	1.1E+06	0.31	179	0
T - Joint	457	228.5	8	0.50	0.50	14.28	4.2E+05	-	1.0E+06	1.3E+06	0.30	179	0
T - Joint	457	457	8.8	1.00	0.55	14.28	1.7E+05	-	1.0E+06	1.2E+06	0.20	192	-1
T - Joint	457	228.5	8	0.50	0.50	14.28	3.5E+05	-	6.8E+05	8.2E+05	0.21	198	0
T - Joint	457	228.5	8	0.50	0.50	14.28	3.2E+05	-	7.6E+05	1.0E+06	0.32	198	0
Y - joint	508	245	10	0.48	0.63	15.88	2.9E+05	5.0E+05	8.0E+05	1.2E+06	0.53	210	-1
T - Joint	508	244.5	10	0.48	0.63	15.88	1.1E+05	-	2.0E+05	1.1E+06	4.35	242	-1
T - Joint	457	228.5	6.2	0.50	0.39	14.28	3.5E+05	-	7.0E+05	9.1E+05	0.30	242	-1
T - Joint	508	244.5	10	0.48	0.63	15.88	1.2E+05	-	1.6E+05	8.7E+05	4.41	273	-1
T - Joint	508	244.5	10	0.48	0.63	15.88	4.5E+05	-	6.5E+05	1.6E+06	1.46	277	-1
NK - Joint	508	305	13.5	0.60	0.84	15.88	9.8E+04	1.2E+05	4.9E+05	1.5E+06	2.04	206	-1
T - Joint	508	244.5	10	0.48	0.63	15.88	5.6E+04	-	7.5E+04	5.8E+05	6.73	350	-1
OK - Joint	508	305	13.5	0.60	0.84	15.88	1.9E+06	-	3.0E+06	4.6E+06	0.53	-	-1
T - Joint	508	244.5	10	0.48	0.63	15.88	-	-	-	-	-	-	-1
T - Joint	508	244.5	10	0.48	0.63	15.88	-	-	3.0E+04	2.1E+05	5.87	438	-1

Some other information about the data:

1. Tested by Gibstein 1981
2. Loading type: AX; Chord Wall Thickness = 16 mm; Constant amplitude loading
3. Weld preparation: As welded

Table Ap1-1.17

Joint Type	Weld	Chord OD (mm)	Brace OD (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)	R ratio
T - Joint	Repair welded + burr ground	457	229	0.50	0.75	14.28	1.1E+04	-	3.1E+05	-	-	336	-1
T - Joint	Hole drilling	457	229	0.50	0.75	14.28	2.0E+04	-	3.0E+05	-	-	351	-1
X - Joint	As welded	457	229	0.50	0.75	14.28	2.1E+04	-	2.5E+05	-	-	353	0
T - Joint	Hole drilling	457	229	0.50	0.75	14.28	6.7E+04	-	1.7E+05	-	-	354	-1
T - Joint	Repair welded + burr ground	457	229	0.50	0.75	14.28	2.3E+04	-	2.2E+05	-	-	379	-1
T - Joint	Repair welded + burr ground	457	229	0.50	0.75	14.28	1.1E+05	-	-	-	-	236.5	-1
T - Joint	Repair welded + burr ground	457	229	0.50	0.75	14.28	6.4E+04	-	-	-	-	318.7	-1
T - Joint	Repair welded + burr ground	457	229	0.50	0.75	14.28	4.3E+04	-	-	-	-	375.3	-1

Some other information about the data:
1. Tested by OTH 89 307
2. Loading type: OPB; Constant amplitude loading
3. Chord Wall Thickness = 16 mm; Brace Wall Thickness = 12 mm

Table Ap1-1.18

Joint Type	Weld	Chord OD (mm)	Brace OD (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)	R ratio
T - Joint	Repair welded	457	229	0.50	0.75	14.28	1.7E+05	-	4.3E+06	-	-	164.8	-1
X - Joint	Repair welded	457	229	0.50	0.75	14.28	1.6E+04	-	4.9E+05	-	-	235.3	0
T - Joint	Repair welded	457	229	0.50	0.75	14.28	3.6E+04	-	6.8E+05	-	-	239	-1
T - Joint	Repair welded	457	229	0.50	0.75	14.28	4.8E+04	-	3.7E+05	-	-	268	0
T - Joint	Repair welded	457	229	0.50	0.75	14.28	2.1E+04	-	4.1E+05	-	-	335.3	-1
T - Joint	Repair welded	457	229	0.50	0.75	14.28	1.6E+05	-	-	-	-	179	-1
T - Joint	Repair welded	457	229	0.50	0.75	14.28	6.2E+04	-	-	-	-	238.9	-1
T - Joint	Repair welded	457	229	0.50	0.75	14.28	3.9E+04	-	-	-	-	376.4	-1
T - Joint	Burr Grinding	457	229	0.50	0.75	14.28	1.0E+05	-	-	-	-	209.9	-1
T - Joint	Burr Grinding	457	229	0.50	0.75	14.28	6.4E+04	-	-	-	-	226.1	-1
T - Joint	Burr Grinding	457	229	0.50	0.75	14.28	1.7E+04	-	-	-	-	333.6	-1
T - Joint	Burr Grinding	457	229	0.50	0.75	14.28	3.1E+05	-	-	-	-	176	-1
T - Joint	Burr Grinding	457	229	0.50	0.75	14.28	4.2E+04	-	-	-	-	245.7	-1
T - Joint	Burr Grinding	457	229	0.50	0.75	14.28	2.1E+04	-	-	-	-	363.2	-1
T - Joint	Burr Grinding	457	229	0.50	0.75	14.28	2.2E+04	-	2.2E+05	-	-	399.6	-1
T - Joint	Burr Grinding	457	229	0.50	0.75	14.28	1.1E+04	-	-	-	-	415.7	-1
T - Joint	Burr Grinding	457	229	0.50	0.75	14.28	-	-	-	-	-	277.2	-1

Some other information about the data:

1. Tested by OTH 89 307
2. Loading type: OPB; Constant amplitude loading
3. Chord Wall Thickness = 16 mm; Brace Wall Thickness = 12 mm

Table Ap1-1.19

Joint Type	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)	R ratio
T - Joint	457	16	457	16	1.00	1.00	14.28	2.8E+05	2.5E+06	7.0E+06	8.7E+06	0.26	120	-1
T - Joint	457	16	457	8.8	1.00	0.55	14.28	1.2E+06	1.3E+06	2.0E+06	2.9E+06	0.45	146	-1
T - Joint	457	16	457	16	1.00	1.00	14.28	3.5E+05	6.7E+05	1.0E+06	1.5E+06	0.50	190	-1
OK - Joint	457	16	246.78	8	0.54	0.50	14.28	-	-	-	8.2E+06	-	80	0
NK - Joint	457	16	246.78	8	0.54	0.50	14.28	7.2E+05	7.3E+05	1.1E+06	1.2E+06	0.09	181	0
NK - Joint	457	16	246.78	8	0.54	0.50	14.28	-	2.4E+06	-	4.9E+06	-	142	0
NKT - Joint	457	16	246.78	8	0.54	0.50	14.28	4.2E+04	2.9E+05	6.3E+05	7.3E+05	0.16	194	0
NKT - Joint	457	16	246.78	8	0.54	0.50	14.28	5.2E+04	1.7E+05	-	9.1E+05	-	214	0
T - Joint	457	16	114.25	4.5	0.25	0.28	14.28	1.4E+07	2.2E+07	-	3.0E+07	-	201	-1
T - Joint	457	16	114.25	4.5	0.25	0.28	14.28	-	-	-	1.9E+07	-	268	-1
T - Joint	457	16	114.25	4.8	0.25	0.30	14.28	-	9.5E+05	2.4E+06	3.0E+06	0.25	57.3	-
T - Joint	457	16	114.25	4.8	0.25	0.30	14.28	-	2.0E+05	6.5E+05	9.6E+05	0.48	77.3	-
T - Joint	457	16	114.25	4.8	0.25	0.30	14.28	-	3.0E+06	1.1E+07	1.1E+07	0.06	53.2	-
T - Joint	457	16	114.25	4.8	0.25	0.30	14.28	-	5.6E+06	8.5E+06	1.9E+07	1.20	40.4	-
T - Joint	457	16	457	16	1.00	1.00	14.28	6.0E+04	8.8E+04	1.4E+05	1.5E+05	0.06	322	-1
T - Joint	457	16	457	8.8	1.00	0.55	14.28	-	-	5.4E+05	6.8E+05	0.27	204	-1
T - Joint	457	16	457	8.8	1.00	0.55	14.28	2.3E+05	2.3E+05	3.7E+05	3.9E+05	0.06	269	-1
T - Joint	457	16	114.25	6.2	0.25	0.39	14.28	-	4.5E+05	1.1E+06	1.6E+06	0.41	266	-1
T - Joint	457	16	114.25	6.2	0.25	0.39	14.28	-	6.0E+05	1.3E+06	2.0E+06	0.49	183	-1

Some other information about the data:

1. Tested by UKOSRP I
2. Loading type: AX; Constant amplitude loading
3. Weld preparation: As welded

Table Ap1-1.20

Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	Loading Spectrum	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)	R ratio
457	16	457	8.8	CA	1.00	0.55	14.28	-	2.3E+07	-	3.0E+07	-	170	-1
457	16	114.25	6.2	CA	0.25	0.39	14.28	-	-	-	3.0E+06	-	365	-1
457	16	114.25	6.2	CA	0.25	0.39	14.28	-	-	-	2.4E+06	-	488	-1
457	16	114.25	4.5	CA	0.25	0.28	14.28	-	-	-	2.0E+08	-	230	-1
457	16	457	16	VA	1.00	1.00	14.28	-	-	1.8E+05	2.7E+05	0.50	83	-
457	16	457	16	VA	1.00	1.00	14.28	-	-	1.7E+06	1.0E+07	4.95	37.3	-
457	16	457	16	VA	1.00	1.00	14.28	-	6.5E+05	2.4E+06	4.7E+06	0.96	58.1	-
457	16	457	16	VA	1.00	1.00	14.28	-	2.1E+06	2.8E+06	6.0E+06	1.14	45.3	-
457	16	457	16	CA	1.00	1.00	14.28	8.4E+04	1.3E+05	2.9E+05	5.0E+05	0.72	271	-1
457	16	457	16	CA	1.00	1.00	14.28	2.0E+06	5.0E+06	1.0E+07	1.4E+07	0.44	129	-1
457	16	457	16	CA	1.00	1.00	14.28	3.0E+05	3.4E+05	7.3E+05	1.4E+06	0.98	169	-1
457	16	457	8.8	CA	1.00	0.55	14.28	-	6.0E+05	6.1E+05	1.7E+06	1.79	225	-1
457	16	457	8.8	CA	1.00	0.55	14.28	-	1.3E+06	1.8E+06	5.3E+06	1.96	144	-1
457	16	114.25	6.2	CA	0.25	0.39	14.28	-	1.6E+06	2.2E+06	3.2E+06	0.45	166	-1
457	16	114.25	4.5	CA	0.25	0.28	14.28	-	2.1E+06	3.6E+06	5.3E+06	0.48	315	-1
457	16	114.25	4.5	CA	0.25	0.28	14.28	-	9.0E+04	9.7E+04	1.1E+05	0.13	691	-1
457	16	114.25	4.5	CA	0.25	0.28	14.28	-	1.5E+06	1.7E+06	1.9E+06	0.10	408	-1

Some other information about the data:

1. Tested by UKOSRP I
2. Joint type: T; Loading type: IPB
3. Weld preparation: As welded
4. Constant Amplitude = CA; Variable Amplitude = VA

Table Ap1-1.21

Joint Type	Chord OD (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
OK - Joint	457	246.78	8	0.54	0.50	14.28	6.7E+03	4.0E+04	2.2E+05	3.8E+05	0.73	370
OK - Joint	457	246.78	8	0.54	0.50	14.28	7.8E+04	4.0E+05	4.0E+06	5.3E+06	0.33	166
OK - Joint	457	246.78	12.5	0.54	0.78	14.28	3.0E+04	1.8E+05	1.1E+06	1.8E+06	0.64	271
OK - Joint	457	246.78	12.5	0.54	0.78	14.28	7.1E+03	1.6E+04	1.9E+05	3.2E+05	0.68	322
OKT - Joint	457	246.78	8	0.54	0.50	14.28	3.1E+04	4.4E+04	1.2E+06	2.1E+06	0.75	193
OKT - Joint	457	246.78	8	0.54	0.50	14.28	1.0E+04	3.5E+04	4.6E+05	5.9E+05	0.28	295
OKT - Joint	457	246.78	12.5	0.54	0.78	14.28	3.6E+04	9.4E+04	1.7E+06	2.7E+06	0.59	191
OKT - Joint	457	246.78	12.5	0.54	0.78	14.28	1.0E+04	2.0E+04	3.3E+05	5.9E+05	0.79	282
T - Joint	457	457	16	1.00	1.00	14.28	8.0E+04	3.3E+05	1.1E+06	1.2E+06	0.09	181
T - Joint	457	457	16	1.00	1.00	14.28	1.9E+04	1.6E+05	6.1E+05	8.1E+05	0.33	275
T - Joint	457	457	16	1.00	1.00	14.28	5.7E+05	2.7E+06	7.5E+06	9.7E+06	0.29	137
T - Joint	457	457	8.8	1.00	0.55	14.28	2.4E+04	8.8E+04	2.9E+05	3.7E+05	0.28	314
T - Joint	457	457	8.8	1.00	0.55	14.28	2.9E+04	2.2E+05	9.5E+05	1.5E+06	0.58	184
T - Joint	457	457	8.8	1.00	0.55	14.28	7.7E+04	5.4E+05	3.6E+06	5.9E+06	0.64	135
T - Joint	457	114.25	6.2	0.25	0.39	14.28	2.4E+05	1.0E+06	5.1E+06	1.5E+07	1.94	156
T - Joint	457	114.25	6.2	0.25	0.39	14.28	1.0E+04	2.7E+04	3.7E+05	6.3E+05	0.70	344
T - Joint	457	114.25	6.2	0.25	0.39	14.28	3.5E+04	1.8E+05	9.0E+05	1.2E+06	0.33	154
T - Joint	457	114.25	4.5	0.25	0.28	14.28	4.8E+04	2.2E+05	2.6E+06	4.5E+06	0.73	170
T - Joint	457	114.25	4.5	0.25	0.28	14.28	3.8E+03	2.8E+04	5.8E+04	7.5E+04	0.29	372
T - Joint	457	114.25	4.5	0.25	0.28	14.28	1.8E+04	6.9E+04	2.4E+05	2.9E+05	0.21	281

Some other information about the data:

1. Tested by UKOSRP I
2. Loading type: OPB; Stress Ratio R=0
3. Weld preparation: As welded
4. Loading Spectrum = Constant amplitude

Table Ap1-1.22

Load Case	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)	R ratio
OPB/CEL	457	16	457	16	1.00	1.00	14.28	3.3E+04	5.7E+04	6.7E+05	1.2E+06	0.79	208	0
OPB/CEL	457	16	457	16	1.00	1.00	14.28	7.9E+03	3.5E+04	1.8E+05	3.5E+05	0.94	313	0
OPB/CEL	457	16	457	16	1.00	1.00	14.28	2.0E+05	8.0E+05	4.1E+06	5.2E+06	0.28	117	0
IPB/CEL	457	16	457	16	1.00	1.00	14.28	4.5E+05	4.5E+05	1.2E+06	1.5E+06	0.28	271	-1
IPB/CEL	457	16	457	16	1.00	1.00	14.28	5.0E+05	7.3E+05	3.8E+06	6.2E+06	0.63	183	-1
IPB/CEL	457	16	457	16	1.00	1.00	14.28	-	-	2.4E+05	3.3E+05	0.37	401	-1
AX/CEL	457	16	457	8.8	1.00	0.55	14.28	5.5E+05	1.0E+06	2.1E+06	3.9E+06	0.83	208	-1
AX/CEL	457	16	457	8.8	1.00	0.55	14.28	8.2E+04	7.5E+05	1.1E+06	1.6E+06	0.41	271	-1
AX/CEL	457	16	114.25	6.2	0.25	0.39	14.28	-	1.2E+06	1.8E+06	2.3E+06	0.27	179	-1
AX/CEL	457	16	114.25	6.2	0.25	0.39	14.28	1.9E+05	2.2E+05	3.4E+05	5.5E+05	0.63	254	-1

Some other information about the data:

1. Tested by UKOSRP I
2. Joint type: T
3. Weld preparation: As welded
4. Loading Spectrum = Constant amplitude

Table Ap1-1.23

Joint Type	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)	R ratio
NK - Joint	457	16	244	8	0.53	0.50	14.28	1.4E+04	2.1E+04	3.9E+04	7.5E+04	0.95	619	-1
NK - Joint	457	16	244	8	0.53	0.50	14.28	3.2E+04	7.7E+04	1.4E+05	4.1E+05	1.91	432	-1
NK - Joint	457	16	244	8	0.53	0.50	14.28	1.2E+05	1.5E+05	3.1E+05	5.8E+05	0.85	368	-1
OK - Joint	457	16	244	12.5	0.53	0.78	14.28	*-	1.8E+05	1.8E+05	3.6E+05	0.94	256	-1
OK - Joint	457	16	244	12.8	0.53	0.80	14.28	4.3E+05	9.0E+05	9.5E+05	1.0E+06	0.06	203	-1
OK - Joint	457.2	16	216.3	8	0.47	0.50	14.29	3.4E+04	5.9E+04	6.0E+04	9.0E+04	0.50	390	-1
OK - Joint	457.2	16	216.3	8	0.47	0.50	14.29	7.8E+05	1.0E+06	-	1.2E+06	-	276	-1
OK - Joint	457.2	16	216.3	8	0.47	0.50	14.29	8.6E+04	8.7E+04	-	1.1E+05	-	367	-1
OK - Joint	457.2	16	216.3	8	0.47	0.50	14.29	-	1.1E+06	-	2.0E+06	-	237	-1
OK - Joint	457.2	16	216.3	8	0.47	0.50	14.29	-	6.2E+04	-	1.2E+05	-	460	-1
OK - Joint	457.2	16	216.3	8	0.47	0.50	14.29	1.3E+05	-	-	3.0E+05	-	279	-1
OK - Joint	457	16	244	8	0.53	0.50	14.28	-	-	-	-	-	396	-
OK - Joint	457	16	244	8	0.53	0.50	14.28	3.3E+05	3.5E+05	5.4E+05	-	-	234	-
OK - Joint	457	16	244	8	0.53	0.50	14.28	1.8E+05	-	-	-	-	185	-
OK - Joint	457	16	244	8	0.53	0.50	14.28	4.8E+05	5.4E+05	8.6E+05	1.3E+06	0.52	286	-
OK - Joint	457	16	244	8	0.53	0.50	14.28	3.2E+05	5.4E+05	1.0E+06	1.1E+06	0.06	248	-
OK - Joint	457	16	244	8	0.53	0.50	14.28	4.9E+05	7.1E+05	1.7E+06	-	-	204	-

Some other information about the data:

1. Tested by UKOSRP II
2. Loading type: AX
3. Weld preparation: As welded
4. Loading Spectrum = Constant amplitude

Table Ap1-1.24

Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	Loading Spectrum	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
914	16	457	16	CA	0.50	1.00	28.56	-	2.4E+05	4.9E+06	5.9E+06	0.20	200
914	16	457	16	CA	0.50	1.00	28.56	-	2.2E+05	3.9E+05	4.4E+05	0.13	324
914	16	457	16	CA	0.50	1.00	28.56	-	7.2E+04	2.0E+05	2.3E+05	0.15	450
914	16	457	16	CA	0.50	1.00	28.56	-	1.2E+06	1.5E+06	1.5E+06	0.03	140
914	16	457	16	CA	0.50	1.00	28.56	-	4.0E+04	6.9E+04	6.9E+04	0.01	350
914	16	457	16	CA	0.50	1.00	28.56	-	8.9E+04	1.9E+05	2.0E+05	0.05	250

Some other information about the data:

1. Tested by NEL
2. Loading type: AX; Stress Ratio R=0; Joint type: T
3. Weld preparation: As welded
4. Loading Spectrum = Constant amplitude

Table Ap1-1.25

Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
800	20	368	20	0.46	1.00	20.00	-	2.3E+04	5.0E+04	5.9E+04	0.18	566
800	20	368	20	0.46	1.00	20.00	-	2.3E+04	-	5.9E+04	-	577.5
800	20	368	20	0.46	1.00	20.00	-	7.8E+03	1.7E+04	2.1E+04	0.24	808.5
800	20	368	20	0.46	1.00	20.00	-	7.8E+03	1.9E+04	2.1E+04	0.11	658.4
800	20	368	20	0.46	1.00	20.00	-	8.0E+04	3.8E+05	7.0E+05	0.84	244.9
800	20	368	20	0.46	1.00	20.00	-	9.5E+04	5.0E+05	7.0E+05	0.40	254.1
800	20	368	20	0.46	1.00	20.00	-	2.2E+04	6.2E+04	2.0E+05	2.23	353.4
800	20	368	20	0.46	1.00	20.00	-	7.5E+04	-	2.9E+05	-	331.5
800	20	368	20	0.46	1.00	20.00	-	2.2E+04	4.8E+04	7.9E+04	0.65	452.8
800	20	368	20	0.46	1.00	20.00	-	3.0E+04	6.0E+04	7.9E+04	0.32	480.5

Some other information about the data:

1. Loading type: AX; Stress Ratio R= -1; Joint type: Y
2. Weld preparation: As welded
3. Loading Spectrum = Constant amplitude

Table Ap1-1.26

Joint Type	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
Y - joint	800	20	368	20	0.46	1.00	20.00	1.7E+04	2.3E+04	5.0E+04	5.9E+04	0.18	-
Y - joint	800	20	368	20	0.46	1.00	20.00	1.3E+04	2.3E+04	5.0E+04	5.9E+04	0.18	-
Y - joint	800	20	368	20	0.46	1.00	20.00	5.5E+03	7.8E+03	1.7E+04	2.1E+04	0.24	-
Y - joint	800	20	368	20	0.46	1.00	20.00	5.5E+03	7.8E+03	1.9E+04	2.1E+04	0.11	-
Y - joint	800	20	368	20	0.46	1.00	20.00	6.0E+04	9.0E+04	3.8E+05	7.0E+05	0.84	-
Y - joint	800	20	368	20	0.46	1.00	20.00	8.5E+04	9.5E+04	5.0E+05	7.0E+05	0.40	-

Some other information about the data:

1. Tested by Damilano 1981
2. Weld preparation: As welded
3. Loading Spectrum = Constant amplitude

Table Ap1-1.27

Weld	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
Normal	457	25	273	19	0.60	0.76	9.14	-	9.6E+04	3.6E+05	4.0E+05	0.11	204
Normal	457	25	273	19	0.60	0.76	9.14	-	1.2E+05	4.1E+05	4.6E+05	0.12	201
Flat weld	457	25	273	19	0.60	0.76	9.14	-	6.6E+03	5.1E+04	5.5E+04	0.08	359
Flat weld	457	25	273	19	0.60	0.76	9.14	-	5.1E+03	3.8E+04	4.2E+04	0.11	377
AWS D1.1	457	25	273	19	0.60	0.76	9.14	-	4.9E+04	1.6E+05	1.9E+05	0.19	299
AWS D1.1	457	25	273	19	0.60	0.76	9.14	-	8.9E+03	2.0E+05	2.2E+05	0.10	237
AWS D1.1	457	25	273	19	0.60	0.76	9.14	-	1.1E+05	6.5E+05	7.9E+05	0.22	145
AWS D1.1	457	25	273	19	0.60	0.76	9.14	-	1.9E+05	5.5E+05	6.2E+05	0.13	172
AWS D1.1	457	25	273	19	0.60	0.76	9.14	-	2.1E+05	1.0E+06	1.0E+06	0.01	150
AWS D1.1	457	25	273	19	0.60	0.76	9.14	-	2.5E+05	7.5E+05	8.0E+05	0.07	163
Extended weld with peaky weld beads	457	25	273	19	0.60	0.76	9.14	-	1.6E+05	4.6E+05	4.7E+05	0.02	190
Extended weld with peaky weld beads	457	25	273	19	0.60	0.76	9.14	-	1.1E+05	6.7E+05	7.3E+05	0.09	217
Extended welds with beads weld ground	457	25	273	19	0.60	0.76	9.14	-	9.0E+04	4.4E+05	4.6E+05	0.05	191
Extended welds with beads weld ground	457	25	273	19	0.60	0.76	9.14	-	2.3E+05	7.9E+05	8.6E+05	0.09	164
Toe Ground	457	25	273	19	0.60	0.76	9.14	-	1.1E+03	1.8E+06	2.0E+06	0.11	167
Toe Ground	457	25	273	19	0.60	0.76	9.14	-	1.0E+06	3.0E+06	3.0E+06	0.01	178

Some other information about the data:

4. Tested by TWI
5. Loading type IPB; Stress Ratio R=0; Joint type: T
6. Loading Spectrum = Constant amplitude

Table Ap1-1.28

Weld	Load Case	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
As welded	AX	762	20.6	273	16.7	0.36	0.81	18.50	-	-	-	3.1E+04	-	785
As welded	AX	762	22.5	324	18.9	0.43	0.84	16.93	-	1.2E+04	-	5.7E+05	-	258
As welded	AX	660	28.3	273	16.7	0.41	0.59	11.66	-	6.3E+03	-	7.8E+04	-	521
Casted	AX	660	28.4	273	17.5	0.41	0.62	11.62	-	9.2E+04	-	2.4E+05	-	268

Some other information about the data:
1. Tested by Ohtake 1978
2. Joint type: N; Stress Ratio R= -1
3. Loading Spectrum = Constant amplitude

Table Ap1-1.29

Load Case	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
IPB	472	22	339.84	21.8	0.72	0.99	10.73	5.5E+04	9.1E+04	1.6E+05	1.9E+05	0.20	242
AX	473	23	341.5	21.5	0.72	0.93	10.28	4.8E+04	-	4.6E+05	7.5E+05	0.63	242

Some other information about the data:
1. Tested by Damilano 1981
2. Joint type: T; Stress Ratio R= 0.1
3. Loading Spectrum = Constant amplitude
4. Weld preparation: As welded

Table Ap1-1.30

Weld	Load Case	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
PWHT	IPB	472	22.3	341	22	0.72	0.99	10.58	-	8.2E+04	1.6E+05	1.9E+05	0.19	236
As welded	AX	473	22.8	341	22	0.72	0.94	10.37	-	1.4E+05	4.6E+05	7.5E+05	0.63	242

Some other information about the data:

1. Tested by ECSC
2. Joint type: X; Stress Ratio R= -1
3. Loading Spectrum = Constant amplitude

Table Ap1-1.31

Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
914	32	457	16	0.50	0.50	14.28	5.5E+06	-	2.0E+07	2.6E+07	0.30	75
914	32	457	16	0.50	0.50	14.28	3.8E+06	-	1.2E+07	1.4E+07	0.17	78
914	32	457	16	0.50	0.50	14.28	3.3E+06	-	8.1E+06	1.6E+07	0.98	79
914	32	457	16	0.50	0.50	14.28	1.9E+06	-	4.1E+06	5.0E+06	0.22	94
914	32	457	16	0.50	0.50	14.28	3.7E+05	-	9.5E+05	1.3E+06	0.37	155
914	32	457	16	0.50	0.50	14.28	1.9E+04	1.5E+05	7.0E+05	8.5E+05	0.21	197
914	32	457	16	0.50	0.50	14.28	9.0E+04	-	5.0E+05	7.3E+05	0.46	198
914	32	457	16	0.50	0.50	14.28	1.5E+05	-	4.1E+05	6.8E+05	0.66	217
914	32	457	16	0.50	0.50	14.28	5.0E+04	-	1.5E+05	1.7E+05	0.13	267

Some other information about the data:

1. Tested by Gibstein 1981
2. Joint type: T; Stress Ratio R= 0; Loading type AX
3. Weld preparation: As welded
4. Loading Spectrum = Constant amplitude

Table Ap1-1.32

Weld	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
improved overall weld shape	914.4	32	457.2	16	0.50	0.50	14.29	5.8E+05	5.3E+06	8.2E+06	8.7E+06	0.06	92
Ground	914.4	32	457.2	16	0.50	0.50	14.29	8.5E+05	8.8E+05	1.8E+06	2.1E+06	0.12	145
Ground	914.4	32	457.2	16	0.50	0.50	14.29	7.3E+04	5.4E+05	1.4E+06	1.6E+06	0.14	149
improved overall weld shape	914.4	32	457.2	16	0.50	0.50	14.29	4.5E+04	4.3E+05	1.0E+06	1.1E+06	0.10	153
Ground	914.4	32	457.2	16	0.50	0.50	14.29	1.1E+04	5.4E+04	2.8E+05	3.2E+05	0.15	202

Some other information about the data:

1. Tested by EC – technical steel research
2. Joint type: T; Stress Ratio R= 0; Loading type AX
3. Loading Spectrum = Constant amplitude

Table Ap1-1.33

Weld	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
PWHT	914	32	457	16	0.50	0.50	14.28	-	1.3E+05	3.0E+05	4.0E+05	0.33	200
PWHT	914	32	457	16	0.50	0.50	14.28	-	1.0E+06	2.2E+06	2.6E+06	0.18	170
As welded	914	32	457	16	0.50	0.50	14.28	-	3.0E+06	1.4E+07	1.5E+07	0.07	85

Some other information about the data:

1. Joint type: T; Stress Ratio R= 0; Loading type AX
2. Loading Spectrum = Constant amplitude

Table Ap1-1.34

Load Case	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
AX	914	32	457	8	0.50	0.25	14.28	2.8E+05	1.8E+06	4.8E+06	6.4E+06	0.33	94
AX	914	32	228.5	8	0.25	0.25	14.28	3.0E+05	4.7E+05	1.2E+06	2.8E+06	1.29	188
AX	914	32	457	32	0.50	1.00	14.28	-	-	-	2.0E+08	-	112
IPB	914	32	457	32	0.50	1.00	14.28	-	-	-	2.0E+08	-	52
AX	914	32	228.5	16	0.25	0.50	14.28	-	-	-	2.0E+08	-	78
AX	914	32	228.5	16	0.25	0.50	14.28	-	-	-	2.0E+08	-	86
IPB	914	32	228.5	16	0.25	0.50	14.28	-	-	-	2.0E+08	-	69
AX	914	32	228.5	8	0.25	0.25	14.28	-	-	-	2.0E+08	-	127
IPB	914	32	457	32	0.50	1.00	14.28	2.2E+06	-	2.1E+07	2.6E+07	0.25	77
AX	914	32	457	32	0.50	1.00	14.28	3.0E+05	-	7.7E+05	8.8E+05	0.15	262
AX	914	32	457	32	0.50	1.00	14.28	-	3.5E+05	1.4E+06	2.3E+06	0.66	164
IPB	914	32	457	32	0.50	1.00	14.28	1.1E+06	1.2E+06	3.5E+06	4.9E+06	0.42	108
IPB	914	32	457	32	0.50	1.00	14.28	1.5E+04	9.0E+04	5.3E+05	9.0E+05	0.70	121
AX	914	32	457	8	0.50	0.25	14.28	2.5E+06	-	1.5E+07	1.5E+07	0.05	77
IPB	914	32	457	8	0.50	0.25	14.28	1.1E+06	1.2E+06	2.2E+06	3.3E+06	0.49	92
AX	914	32	228.5	16	0.25	0.50	14.28	1.1E+04	-	2.1E+05	2.4E+05	0.14	294
AX	914	32	228.5	16	0.25	0.50	14.28	7.6E+04	-	2.4E+06	3.3E+06	0.39	147
IPB	914	32	228.5	16	0.25	0.50	14.28	1.3E+05	1.4E+05	1.7E+05	2.5E+05	0.42	279
IPB	914	32	228.5	16	0.25	0.50	14.28	-	2.9E+06	7.5E+06	8.9E+06	0.19	90
IPB	914	32	228.5	8	0.25	0.25	14.28	8.0E+05	9.0E+05	1.2E+06	2.1E+06	0.84	221
IPB	914	32	228.5	8	0.25	0.25	14.28	-	-	2.8E+06	7.3E+06	1.59	175
AX	914	32	228.5	8	0.25	0.25	14.28	-	8.0E+04	1.5E+05	2.3E+05	0.56	380

Some other information about the data:

1. Tested by UKOSRP I
2. Joint type: T; Stress Ratio R= -1
3. Weld preparation: As welded
4. Loading Spectrum = Constant amplitude

Table Ap1-1.35

Weld	Load Case	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
As welded	AX	914	32	457	16	0.50	0.50	14.28	6.0E+05	8.0E+05	1.9E+06	2.3E+06	0.18	166
PWHT		914	32	457	16	0.50	0.50	14.28	-	7.0E+04	2.1E+05	2.8E+05	0.32	460
PWHT		914	32	457	16	0.50	0.50	14.28	1.0E+05	1.4E+05	3.4E+05	4.5E+05	0.32	380
PWHT		914	32	457	16	0.50	0.50	14.28	7.0E+05	9.0E+05	1.5E+06	1.8E+06	0.17	300
PWHT		914	32	457	16	0.50	0.50	14.28	1.3E+06	2.5E+06	6.4E+06	7.8E+06	0.22	221
As welded	AX	914	32	457	16	0.50	0.50	14.28	2.6E+05	4.0E+05	1.1E+06	1.3E+06	0.23	200
As welded	AX	914	32	457	16	0.50	0.50	14.28	1.6E+05	2.2E+05	6.7E+05	7.3E+05	0.08	198

Some other information about the data:
1. Tested by UKOSRP II
2. Joint type: T
3. Loading Spectrum = Constant amplitude

Table Ap1-1.36

Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	Loading Spectrum	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
914	32	457	16	CA	0.50	0.50	14.28	-	-	-	-	-	200
914	32	457	16	CA	0.50	0.50	14.28	-	-	1.4E+05	1.6E+05	0.14	200
914	32	457	16	CA	0.50	0.50	14.28	-	-	6.0E+05	6.6E+05	0.10	100
914	32	457	16	CA	0.50	0.50	14.28	-	-	8.6E+05	9.0E+05	0.05	100

Some other information about the data:
1. Loading type: IPB; Joint type: T; Stress Ratio R= -1
2. Loading Spectrum = Constant amplitude
3. Weld preparation: As welded

Table Ap1-1.37

Load Case	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
IPB	685	40	342.5	22	0.50	0.55	8.56	1.1E+05	2.6E+05	6.5E+05	7.6E+05	0.17	146
AX	684	40	340.4	22.4	0.50	0.56	8.55	2.1E+05	-	4.0E+05	5.8E+05	0.45	192
AX	949	42	342.4	22.4	0.36	0.53	11.30	6.0E+04	-	3.0E+05	4.4E+05	0.45	227
IPB	947	44	681.84	43.6	0.72	0.99	10.76	1.3E+05	2.1E+05	4.7E+05	6.5E+05	0.38	126

Some other information about the data:

1. Tested by Damilano 1981
2. Joint type: T; Stress Ratio R= 0.1
3. Weld preparation: As welded
4. Loading Spectrum = Constant amplitude

Table Ap1-1.38

Weld	Load Case	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
PWHT	AX	684	40	341	22	0.50	0.56	8.55	-	1.7E+05	4.0E+05	5.8E+05	0.45	176
As welded	IPB	685	40	343	22	0.50	0.55	8.56	-	1.3E+05	6.5E+05	7.6E+05	0.17	134
As welded	AX	948.6	41.6	682	41	0.72	1.00	11.40	-	6.0E+04	3.3E+05	4.4E+05	0.33	208
As welded	IPB	947	44	683	44	0.72	0.99	10.76	-	1.6E+05	4.7E+05	6.5E+05	0.38	116

Some other information about the data:

5. Tested by ECSC
6. Joint type: X; Stress Ratio R= 0.1
7. Loading Spectrum = Constant amplitude

Table Ap1-1.39

Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
640	40	215	-	0.50	0.5	8.00	2.2E+06	3.6E+06	9.0E+06	-	-	79.7

Some other information about the data:
1. Loading type: IPB; Joint type: X; Stress Ratio R= 0.1
2. Weld preparation: As welded
3. Loading Spectrum = Constant amplitude

Table Ap1-1.40

Load Case	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
IPB	1830	75	457.5	18.8	0.25	0.25	12.20	-	-	-	2.0E+08	-	100
IPB	1830	75	915	37.5	0.50	0.50	12.20	-	-	-	2.0E+08	-	102
AX	1830	75	457.5	18.8	0.25	0.25	12.20	-	-	1.1E+06	1.3E+06	0.18	168
AX	1830	75	457.5	18.8	0.25	0.25	12.20	-	-	5.0E+05	6.6E+05	0.33	233
AX	1830	75	915	37.5	0.50	0.50	12.20	2.2E+04	1.9E+05	6.4E+05	7.4E+05	0.16	222
AX	1830	75	915	37.5	0.50	0.50	12.20	4.8E+05	5.3E+05	3.1E+06	4.3E+06	0.38	157
IPB	1830	75	457.5	18.8	0.25	0.25	12.20	-	5.3E+04	9.5E+04	1.1E+05	0.16	409
IPB	1830	75	457.5	18.8	0.25	0.25	12.20	1.8E+05	2.2E+05	3.3E+05	3.6E+05	0.08	330
IPB	1830	75	915	37.5	0.50	0.50	12.20	-	2.6E+04	1.1E+05	1.5E+05	0.33	324
IPB	1830	75	915	37.5	0.50	0.50	12.20	-	1.1E+06	1.3E+06	1.6E+06	0.16	156

Some other information about the data:
1. Tested by UKOSRP I
2. Joint type: T; Stress Ratio R= 0.1
3. Welded preparation: PHWT
4. Loading Spectrum = Constant amplitude

Table Ap1-1.41

Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
1830	75	915	37.5	0.50	0.50	12.20	-	7.6E+04	3.3E+05	3.3E+05	0.01	204
1830	75	915	37.5	0.50	0.50	12.20	-	4.3E+05	2.9E+06	3.2E+06	0.12	115
1830	75	915	37.5	0.50	0.50	12.20	1.5E+04	-	1.2E+05	1.4E+05	0.16	288
1830	75	915	37.5	0.50	0.50	12.20	3.5E+05	4.3E+05	9.1E+05	1.1E+06	0.20	156

Some other information about the data:

5. Tested by UKOSRP II
6. Joint type: H; Stress Ratio R= -1
7. Welded preparation: As welded
8. Loading Spectrum = Constant amplitude

Table Ap1-1.42

Load Case	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
AX	1280	75	683	40	0.53	0.53	8.53	8.0E+04	-	6.6E+05	9.1E+05	0.38	129
IPB	1275	75	344.25	22.5	0.27	0.30	8.50	3.0E+04	1.8E+05	6.5E+05	6.6E+05	0.02	166
IPB	1273	77	687.42	43.9	0.54	0.57	8.27	4.0E+04	8.9E+04	4.6E+05	5.5E+05	0.20	126
AX	1281	78	682	41.4	0.53	0.53	8.21	2.6E+05	-	1.1E+06	1.3E+06	0.15	111

Some other information about the data:

1. Tested by Damilano 1981
2. Joint type: T; Stress Ratio R= 0.1
3. Weld preparation: As welded
4. Loading Spectrum = Constant amplitude

Table Ap1-1.43

Weld	Load Case	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
As welded	AX	1280	75	683	40	0.53	0.53	8.53	-	1.3E+05	6.6E+05	9.1E+05	0.38	118
As welded	IPB	1275	75	343	23	0.27	0.30	8.50	-	1.6E+05	6.5E+05	6.6E+05	0.02	152
PWHT	IPB	1273	76.7	684	44	0.54	0.57	8.30	-	5.9E+04	5.1E+05	5.5E+05	0.08	116
PWHT	AX	1280.6	77.6	343	22	0.27	0.29	8.25	-	2.3E+05	1.1E+06	1.3E+06	0.18	116

Some other information about the data:

9. Tested by ECSC
10. Joint type: X; Stress Ratio R= 0.1
11. Loading Spectrum = Constant amplitude

Seawater free corrosion data environment

Table Ap1-2.1

Weld	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
As welded	168	6	89	5	0.53	0.83	14.00	-	7.6E+04	4.7E+05	6.7E+05	0.43	252
As welded	168	6	89	5	0.53	0.83	14.00	-	9.0E+04	1.8E+06	2.5E+06	0.39	216
As welded	168	6	89	3	0.53	0.50	14.00	-	1.2E+04	2.2E+05	3.3E+05	0.50	313
As welded	168	6	89	3	0.53	0.50	14.00	-	1.2E+04	8.8E+04	1.2E+05	0.36	425

Some other information about the data:

4. Tested by TWI
5. Loading type: OPB; Stress ratio R=0; Joint Type: OK
6. Loading Spectrum: Constant Amplitude

Table Ap1-2.2

Weld	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	Loading Spectrum	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
As welded	319	9.4	133	7	CA	0.42	0.69	16.97	-	7.6E+04	4.7E+05	6.7E+05	0.43	252
Toe Ground	319	9.4	133	7	VA	0.42	0.69	16.97	-	9.0E+04	1.8E+06	2.5E+06	0.39	216
Toe Ground	319	9.4	133	7	CA	0.42	0.69	16.97	-	1.2E+04	2.2E+05	3.3E+05	0.50	313
As welded	319	9.4	133	7	CA	0.42	0.69	16.97	-	1.2E+04	8.8E+04	1.2E+05	0.36	425

Some other information about the data:

1. Tested by Canadian Researchers
2. Loading type: AX
3. Constant Amplitude = CA; Variable Amplitude = VA

Table Ap1-2.3

Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)	R ratio
508	16	244.5	10	0.48	0.63	15.88	7.5E+04	-	2.2E+05	5.9E+05	1.69	-	-1
508	16	244.5	10	0.48	0.63	15.88	1.9E+06	-	2.4E+06	3.9E+06	0.63	-	-1
457	16	228.5	8	0.50	0.50	14.28	1.0E+06	-	2.2E+06	2.7E+06	0.23	106	-1
457	16	228.5	8	0.50	0.50	14.28	1.0E+06	-	2.3E+06	2.8E+06	0.22	106	0

Some other information about the data:

1. Tested by Gibstein 1981
2. Loading type: AX; Joint Type: T
3. Loading Spectrum: Constant Amplitude
4. Weld preparation: As welded

Table Ap1-2.4

Weld	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
Toe Ground	457	20	273	20	0.60	1.00	11.43	-	2.4E+05	4.9E+05	5.8E+05	0.18	206
Toe Ground	457	20	273	20	0.60	1.00	11.43	-	9.3E+04	2.9E+05	4.2E+05	0.45	290
Toe Ground	457	20	273	20	0.60	1.00	11.43	-	1.4E+05	4.7E+05	5.8E+05	0.23	224
As welded	457	20	273	20	0.60	1.00	11.43	-	3.2E+04	4.8E+05	9.5E+05	0.98	227
As welded	457	20	273	20	0.60	1.00	11.43	-	7.1E+04	1.9E+05	2.9E+05	0.53	275

Some other information about the data:

1. Tested by TWI
2. Loading type: OPB; Stress Ratio R = 0; Joint Type: T
3. Loading Spectrum: Constant Amplitude

Table Ap1-2.5

Reference	Weld	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)
EC - technical steel research	As welded	914.4	32	457.2	16	0.50	0.50	14.29	1.0E+05	7.6E+05	2.0E+06	2.2E+06	0.12	79
EC - technical steel research	Ground	914.4	32	457.2	16	0.50	0.50	14.29	5.0E+04	3.5E+05	7.4E+05	8.1E+05	0.09	122
EC - technical steel research	Ground	914.4	32	457.2	16	0.50	0.50	14.29	1.4E+05	7.6E+05	2.2E+06	2.3E+06	0.04	81
Gibstein 1981	As welded	914	32	457	16	0.50	0.50	14.28	1.2E+06	-	3.7E+06	4.3E+06	0.16	82
-	PWHT	914	32	457	16	0.50	0.50	14.28	-	-	1.5E+06	1.7E+06	0.13	81
-	As welded	914	32	457	16	0.50	0.50	14.28	-	-	-	-	-	72

Some other information about the data:

1. Loading type: AX; Stress Ratio R = 0; Joint Type: T
2. Loading Spectrum: Constant Amplitude

Seawater with cathodic protection data environment

Table Ap1-3.1

Joint Type	Weld	Chord OD (mm)	Chord Wall Thickness (mm)	Brace OD (mm)	Brace Wall Thickness (mm)	β	τ	γ	N2	N3	N4	Re	Hot Spot Stress (MPa)
OK - Joint	As welded	168	6	89	5	0.53	0.83	14.00	4.1E+04	1.6E+05	7.3E+05	3.56	347
OK - Joint	As welded	168	6	89	3	0.53	0.50	14.00	1.6E+04	7.3E+04	1.5E+05	1.05	416
T - Joint	Toe Ground	457	20	273	20	0.60	1.00	11.43	6.6E+04	2.4E+05	2.8E+05	0.17	281
T - Joint	Toe Ground	457	20	273	20	0.60	1.00	11.43	1.7E+05	8.3E+05	9.1E+05	0.10	233

Some other information about the data:

1. Tested by TWI
2. Loading type: OPB; Stress Ratio R = 0
3. Loading Spectrum: Constant Amplitude

Table Ap1-3.2

Reference	Weld	Load Case	Chord OD (mm)	Brace OD (mm)	β	τ	γ	N1	N2	N3	N4	Re	Hot Spot Stress (MPa)	R ratio
UKOSRP II	As welded	-	914	457	0.50	0.50	14.28	-	8.5E+04	2.9E+05	3.9E+05	0.33	230	-
UKOSRP II	As welded	-	914	457	0.50	0.50	14.28	-	2.9E+05	5.9E+05	1.0E+06	0.69	166	-
EC - technical steel research	As welded	AX	914.4	457.2	0.50	0.50	14.29	-	-	-	-	-	85	0
EC - technical steel research	Ground	AX	914.4	457.2	0.50	0.50	14.29	-	-	-	-	-	83	0
Gibstein 1981	As welded	AX	914	457	0.50	0.50	14.28	2.4E+06	-	3.9E+06	4.3E+06	0.10	82	0
NEL	As welded	AX	914	457	0.50	0.50	14.28	-	6.6E+04	1.4E+05	1.4E+05	0.01	293	-1
NEL	As welded	AX	914	457	0.50	0.50	14.28	-	1.2E+06	1.8E+06	2.4E+06	0.33	120	-1

Some other information about the data:

1. Joint type: T
2. Loading Spectrum: Constant Amplitude
3. Chord Wall Thickness = 32 mm; Brace Wall Thickness = 16mm

8. Appendix 2: Analysis Zhang and Wintle

Zhang and Wintle Report

Table 1: Remaining life for database of through-thickness cracked members

Sample size	Mean Re	SD	COV
281	0.443	0.531	1.20

Collection of Zhang Database

Table1: Remaining life for database of through-thickness cracked members

Sample size	Mean Re	SD	COV
285	0.440	0.520	1.18

Full database

Table1: Remaining life for database of through-thickness cracked members

Sample size	Mean Re	SD	COV
335	0.495	0.743	1.50

Comparison Zhang & Wintle table with collection of Zhang & Wintle database

Table 2: Remaining life statistics for key variables (Sample size)

Variable	Condition compared	Report Sample size	Database Sample size	Difference of Report - Database
Assessment of stress ratio effect on Re	R=0	5	5	0
	R=-1	5	13	-8
Effect of β on Re for T joints tested under OPB loading (D = 168 mm and T=6mm)	β=0.53	6	6	0
	β=1	6	6	0
Effect of β on Re for T joints tested under OPB loading (D = 457 mm and T=16mm)	β=0.25	6	6	0
	β=1	3	6	-3
Effect of β on Re for T joints tested under AX loading (D = 457 mm and T=16mm)	β=0.5	5	7	-2
	β=1	3	9	-6
Effect of parameter τ on Re under axial loading	τ=0.55	5	3	2
	τ=1	3	6	-3
Effect of parameter τ on Re under OPB loading (T=16mm)	τ=0.6	3	0	3
	τ=1	3	3	0
Effect of chord wall thickness on Re under AX	T=6mm	17	23	-6
	T=16mm	20	28	-8
	T=32mm	21	34	-13
	T=76mm	4	5	-1
Effect of chord wall thickness on Re under OPB	T=6mm	12	12	0
	T=16mm	12	12	0
Effect of chord wall thickness on Re under IPB	T=6mm	14	16	-2
	T=16mm	6	10	-4
Effect of loading mode on Re for T joints with T=6 mm	AX	17	23	-6
	OPB	12	12	0
Effect of loading mode on Re for T joints with T=16 mm	AX	20	28	-8
	OPB	12	12	0
Effect of loading mode on Re for K and KT joints with Thickness = 16 mm	AX	2	5	-3
	OPB	8	8	0
Comparison of Re values between AX and IPB modes at T=6 mm (T joints)	AX	17	23	-6
	IPB	14	16	-2
Comparison of Re values between AX and IPB modes at T=16 mm (T joints)	AX	20	28	-8
	IPB	6	10	-4
Comparison of Re valued between O and N for K and KT joints	OK and OKT joints	6	12	-6
	NK and NKT joints	2	2	0

Variable	Condition compared	Report Sample size	Database Sample size	Difference of Report - Database
Comparison of Re valued between T and K/KT Joints with T=6 mm OPB	T joints	12	12	0
	K and KT joints	8	6	2
Comparison of Re valued between T and K/KT Joints with T=16 mm OPB	T joints	12	12	0
	K and KT joints	8	0	8
Comparison of Re values between T and Y joints under axial loading	T joints, T=16mm	20	8	12
	Y joints, T=20mm	5	9	-4
Mean Re values of X joints tested under AX and IPB	AX	5	5	0
	IPB	5	5	0
Effect of PWHT on Re for specimens with chord thickness of 32mm tested under AX	As welded	21	24	-3
	PWHT	6	3	3
Effect of PWHT on Re for specimens with chord thickness of 76mm tested under IPB	As welded	2	2	0
	PWHT	4	4	0
Damilano - Comparison of Re values between stiffened and unstiffened Y joints	Unstiffened	5	5	0
	Stiffened	3	3	0
UKOSRP II - Comparison of Re values between stiffened and unstiffened Y joints	Unstiffened	5	0	5
	Flexible Ring	3	3	0
	Stiff ring	3	3	0
Comparison of weld profile effect on Re	Type A	2	2	0
	Type B	2	2	0
	Type C	6	6	0
	Type D	2	2	0
	Type E	2	2	0
	Type F	2	2	0
Effect of weld toe grinding on Re under OPB in seawater environment	As-welded, Seawater FC	2	2	0
	Weld toe ground, Seawater FC	3	3	0
	Weld toe ground, Seawater + CP	2	2	0
Effect of environment on Re for K and KT joints under OPB	Air	8	8	0
	Seawater FC	4	4	0
	Seawater + CP	2	2	0
Effect of environment on Re for T joints with T=32mm under AX	Air	3	28	-25
	Seawater FC	-	4	-4
	Seawater + CP	4	2	2

Variable	Condition compared	Report Sample size	Database Sample size	Difference of Report - Database
Variable amplitude effect on Re under AX at T=6.3mm	CA	17	12	5
	VA	11	11	0
Variable amplitude effect on Re under AX at T=16mm	CA	20	24	-4
	VA	4	4	0
Variable amplitude effect on Re under IPB at T=6.3mm	CA	14	13	1
	VA	3	3	0
Variable amplitude effect on Re under IPB at T=16mm	CA	6	6	0
	VA	4	4	0
Effect of compressive end load on chord on Re under AX of T=6mm	no	17	23	-6
	yes	3	8	-5
Effect of compressive end load on chord on Re under AX of T=16mm	no	20	22	-2
	yes	2	4	-2
Effect of compressive end load on chord on Re under IPB of T=6mm	no	14	16	-2
	yes	2	3	-1
Effect of compressive end load on chord on Re under IPB of T=16mm	no	6	10	-4
	yes	2	3	-1
Effect of compressive end load on chord on Re under OPB of T=6mm	no	12	12	0
	yes	3	3	0
Effect of compressive end load on chord on Re under OPB of T=16mm	no	12	12	0
	yes	3	3	0
Effect of HSS range magnitude on Re for AX	HSS<200	5	18	-13
	HSS>=200	7	10	-3
Effect of HSS range magnitude on Re for OPB	HSS<200	8	7	1
	HSS>=200	7	5	2
Effect of HSS range magnitude on Re for IPB	HSS<200	5	8	-3
	HSS>=200	4	2	2
Girth welded pipes OD=324mm and Thickness=12.7mm	-	7	7	0

Comparison Zhang & Wintle table with collection of Zhang & Wintle database

Continuation of Table 2: Remaining life statistics for key variables (RE)

Variable	Condition compared	Report Mean Re	Database Mean Re	Difference of Report – Database Mean Re
Assessment of stress ratio effect on Re	R=0	0.253	0.254	-0.001
	R=-1	0.22	0.277	-0.057
Effect of β on Re for T joints tested under OPB loading (D = 168 mm and T=6mm)	β=0.53	1.057	1.058	-0.001
	β=1	1.08	1.080	0.000
Effect of β on Re for T joints tested under OPB loading (D = 457 mm and T=16mm)	β=0.25	0.699	0.700	-0.001
	β=1	0.498	0.368	0.130
Effect of β on Re for T joints tested under AX loading (D = 457 mm and T=16mm)	β=0.5	0.253	0.256	-0.003
	β=1	0.254	0.242	0.012
Effect of parameter τ on Re under axial loading	τ=0.55	0.4	0.260	0.140
	τ=1	0.279	0.233	0.046
Effect of parameter τ on Re under OPB loading (T=16mm)	τ=0.6	0.498	-	0.498
	τ=1	0.237	0.237	0.000
Effect of chord wall thickness on Re under AX	T=6mm	0.288	0.310	-0.022
	T=16mm	0.289	0.265	0.024
	T=32mm	0.38	0.277	0.103
	T=76mm	0.142	0.286	-0.144
Effect of chord wall thickness on Re under OPB	T=6mm	1.069	1.069	0.000
	T=16mm	0.533	0.534	-0.001
Effect of chord wall thickness on Re under IPB	T=6mm	0.377	0.358	0.019
	T=16mm	1.025	1.389	-0.364
Effect of loading mode on Re for T joints with T=6 mm	AX	0.288	0.310	-0.022
	OPB	1.069	1.069	0.000
Effect of loading mode on Re for T joints with T=16 mm	AX	0.289	0.265	0.024
	OPB	0.533	0.534	-0.001
Effect of loading mode on Re for K and KT joints with Thickness = 16 mm	AX	0.125	1.515	-1.390
	OPB	0.598	1.205	-0.607
Comparison of Re values between AX and IPB modes at T=6 mm (T joints)	AX	0.288	0.310	-0.022
	IPB	0.377	0.358	0.019
Comparison of Re values between AX and IPB modes at T=16 mm (T joints)	AX	0.289	0.265	0.024
	IPB	1.025	1.389	-0.364
Comparison of Re valued between O and N for K and KT joints	OK and OKT joints	0.287	0.668	-0.381
	NK and NKT joints	0.65	0.650	0.000

Variable	Condition compared	Report Sample size	Databas e Sample size	Difference of Report - Database
Comparison of Re valued between T and K/KT Joints with T=6 mm OPB	T joints	1.069	1.069	0.000
	K and KT joints	0.378	0.970	-0.592
Comparison of Re valued between T and K/KT Joints with T=16 mm OPB	T joints	0.533	0.534	-0.001
	K and KT joints	0.598	-	0.598
Comparison of Re values between T and Y joints under axial loading	T joints, T=16mm	0.289	0.621	-0.332
	Y joints, T=20mm	0.352	0.242	0.110
Mean Re values of X joints tested under AX and IPB	AX	0.377	0.394	-0.017
	IPB	0.174	0.168	0.006
Effect of PWHT on Re for specimens with chord thickness of 32mm tested under AX	As welded	0.38	0.337	0.043
	PWHT	0.258	0.213	0.045
Effect of PWHT on Re for specimens with chord thickness of 76mm tested under IPB	As welded	0.105	0.220	-0.115
	PWHT	0.2	0.183	0.018
Damilano - Comparison of Re values between stiffened and unstiffened Y joints	Unstiffened	0.352	0.354	-0.002
	Stiffened	1.063	1.067	-0.004
UKOSRP II - Comparison of Re values between stiffened and unstiffened Y joints	Unstiffened	0.4	0.000	0.400
	Flexible Ring	0.149	0.160	-0.011
	Stiff ring	0.019	0.030	-0.011
Comparison of weld profile effect on Re	Type A	0.129	0.115	0.014
	Type B	0.092	0.095	-0.003
	Type C	0.12	0.120	0.000
	Type D	0.065	0.055	0.010
	Type E	0.069	0.070	-0.001
	Type F	0.054	0.060	-0.006
Effect of weld toe grinding on Re under OPB in seawater environment	As-welded, Seawater FC	0.759	0.755	0.004
	Weld toe ground, Seawater FC	0.285	0.287	-0.002
	Weld toe ground, Seawater + CP	0.134	0.135	-0.001
Effect of environment on Re for K and KT joints under OPB	Air	0.378	1.190	-0.812
	Seawater FC	0.419	0.420	-0.001
	Seawater + CP	2.308	2.305	0.003

Variable	Condition compared	Report Sample size	Databas e Sample size	Difference of Report - Database
Effect of environment on Re for T joints with T=32mm under AX	Air	0.166	0.311	-0.145
	Seawater FC	-	0.095	-0.095
	Seawater + CP	0.34	0.170	0.170
Variable amplitude effect on Re under AX at T=6.3mm	CA	0.288	0.288	0.000
	VA	0.332	0.334	-0.002
Variable amplitude effect on Re under AX at T=16mm	CA	0.289	0.227	0.062
	VA	0.496	0.498	-0.002
Variable amplitude effect on Re under IPB at T=6.3mm	CA	0.377	0.385	-0.008
	VA	0.241	0.240	0.001
Variable amplitude effect on Re under IPB at T=16mm	CA	1.025	1.057	-0.032
	VA	1.882	1.888	-0.006
Effect of compressive end load on chord on Re under AX of T=6mm	no	0.288	0.310	-0.022
	yes	0.348	0.308	0.041
Effect of compressive end load on chord on Re under AX of T=16mm	no	0.289	0.312	-0.023
	yes	0.617	0.535	0.082
Effect of compressive end load on chord on Re under IPB of T=6mm	no	0.377	0.358	0.019
	yes	0.113	0.163	-0.050
Effect of compressive end load on chord on Re under IPB of T=16mm	no	1.025	1.389	-0.364
	yes	0.441	0.427	0.014
Effect of compressive end load on chord on Re under OPB of T=6mm	no	1.069	1.069	0.000
	yes	1.376	1.390	-0.014
Effect of compressive end load on chord on Re under OPB of T=16mm	no	0.533	0.534	-0.001
	yes	0.666	0.670	-0.004
Effect of HSS range magnitude on Re for AX	HSS<200	0.393	0.322	0.071
	HSS>=200	0.385	0.164	0.221
Effect of HSS range magnitude on Re for OPB	HSS<200	0.611	0.657	-0.046
	HSS>=200	0.501	0.362	0.139
Effect of HSS range magnitude on Re for IPB	HSS<200	0.87	1.423	-0.553
	HSS>=200	0.784	1.255	-0.471
Girth welded pipes OD=324mm and Thickness=12.7mm	-	0.086	0.084	0.002

Comparison Zhang & Wintle table with collection of Zhang & Wintle database

Continuation of Table 2: Remaining life statistics for key variables (SD)

Variable	Condition compared	Report SD	Database SD	Difference of Report – Database SD
Assessment of stress ratio effect on Re	R=0	0.072	0.082	-0.010
	R=-1	0.045	0.148	-0.103
Effect of β on Re for T joints tested under OPB loading (D = 168 mm and T=6mm)	β=0.53	0.584	0.640	-0.056
	β=1	0.353	0.386	-0.033
Effect of β on Re for T joints tested under OPB loading (D = 457 mm and T=16mm)	β=0.25	0.591	0.646	-0.055
	β=1	0.159	0.206	-0.047
Effect of β on Re for T joints tested under AX loading (D = 457 mm and T=16mm)	β=0.5	0.072	0.071	0.001
	β=1	0.162	0.152	0.010
Effect of parameter τ on Re under axial loading	τ=0.55	0.256	0.195	0.061
	τ=1	0.168	0.147	0.021
Effect of parameter τ on Re under OPB loading (T=16mm)	τ=0.6	0.159	-	0.159
	τ=1	0.105	0.129	-0.024
Effect of chord wall thickness on Re under AX	T=6mm	0.218	0.209	0.009
	T=16mm	0.143	0.232	-0.089
	T=32mm	0.301	0.277	0.024
	T=76mm	0.089	0.108	-0.019
Effect of chord wall thickness on Re under OPB	T=6mm	0.483	0.504	-0.021
	T=16mm	0.469	0.489	-0.020
Effect of chord wall thickness on Re under IPB	T=6mm	0.262	0.260	0.002
	T=16mm	0.625	1.358	-0.733
Effect of loading mode on Re for T joints with T=6 mm	AX	0.218	0.209	0.009
	OPB	0.483	0.504	-0.021
Effect of loading mode on Re for T joints with T=16 mm	AX	0.143	0.232	-0.089
	OPB	0.469	0.489	-0.020
Effect of loading mode on Re for K and KT joints with Thickness = 16 mm	AX	0.034	1.704	-1.670
	OPB	0.18	0.412	-0.232
Comparison of Re values between AX and IPB modes at T=6 mm (T joints)	AX	0.218	0.209	0.009
	IPB	0.262	0.260	0.002
Comparison of Re values between AX and IPB modes at T=16 mm (T joints)	AX	0.143	0.232	-0.089
	IPB	0.625	1.358	-0.733
Comparison of Re valued between O and N for K and KT joints	OK and OKT joints	0.106	0.939	-0.833
	NK and NKT joints	0.239	0.339	-0.100

Variable	Condition compared	Report Sampl e size	Database Sample size	Difference of Report - Database
Comparison of Re valued between T and K/KT Joints with T=6 mm OPB	T joints	0.483	0.504	-0.021
	K and KT joints	0.218	0.469	-0.251
Comparison of Re valued between T and K/KT Joints with T=16 mm OPB	T joints	0.469	0.489	-0.020
	K and KT joints	0.18	-	0.180
Comparison of Re values between T and Y joints under axial loading	T joints, T=16mm	0.143	0.695	-0.552
	Y joints, T=20mm	0.263	0.152	0.111
Mean Re values of X joints tested under AX and IPB	AX	0.166	0.165	0.001
	IPB	0.122	0.137	-0.015
Effect of PWHT on Re for specimens with chord thickness of 32mm tested under AX	As welded	0.301	0.308	-0.007
	PWHT	0.071	0.104	-0.033
Effect of PWHT on Re for specimens with chord thickness of 76mm tested under IPB	As welded	0.09	0.012	0.078
	PWHT	0.104	0.105	-0.001
Damilano - Comparison of Re values between stiffened and unstiffened Y joints	Unstiffened	0.833	0.292	0.541
	Stiffened	0.187	1.021	-0.834
UKOSRP II - Comparison of Re values between stiffened and unstiffened Y joints	Unstiffened	0.255	0.000	0.255
	Flexible Ring	0.036	0.036	0.000
	Stiff ring	0.02	0.020	0.000
Comparison of weld profile effect on Re	Type A	0.0033	0.007	-0.004
	Type B	0.013	0.021	-0.008
	Type C	0.056	0.077	-0.021
	Type D	0.036	0.049	-0.013
	Type E	0.023	0.028	-0.005
	Type F	0.051	0.071	-0.020
Effect of weld toe grinding on Re under OPB in seawater environment	As-welded, Seawater FC	0.218	0.318	-0.100
	Weld toe ground, Seawater FC	0.105	0.144	-0.039
	Weld toe ground, Seawater + CP	0.04	0.049	-0.009
Effect of environment on Re for K and KT joints under OPB	Air	0.218	0.497	-0.279
	Seawater FC	0.051	0.061	-0.010
	Seawater + CP	1.254	1.775	-0.521
Effect of environment on Re for T joints with T=32mm under AX	Air	0.06	0.291	-0.231
	Seawater FC	-	0.040	-0.040
	Seawater + CP	0.242	0.226	0.016

Variable	Condition compared	Report Sampl e size	Database Sample size	Difference of Report - Database
Variable amplitude effect on Re under AX at T=6.3mm	CA	0.218	0.216	0.002
	VA	0.198	0.207	-0.009
Variable amplitude effect on Re under AX at T=16mm	CA	0.143	0.141	0.002
	VA	0.433	0.499	-0.066
Variable amplitude effect on Re under IPB at T=6.3mm	CA	0.262	0.281	-0.019
	VA	0.073	0.087	-0.014
Variable amplitude effect on Re under IPB at T=16mm	CA	0.625	0.667	-0.042
	VA	1.79	2.059	-0.269
Effect of compressive end load on chord on Re under AX of T=6mm	no	0.218	0.209	0.009
	yes	0.143	0.227	-0.084
Effect of compressive end load on chord on Re under AX of T=16mm	no	0.143	0.240	-0.097
	yes	0.212	0.246	-0.034
Effect of compressive end load on chord on Re under IPB of T=6mm	no	0.262	0.260	0.002
	yes	0.086	0.119	-0.033
Effect of compressive end load on chord on Re under IPB of T=16mm	no	0.625	1.358	-0.733
	yes	0.191	0.182	0.009
Effect of compressive end load on chord on Re under OPB of T=6mm	no	0.483	0.504	-0.021
	yes	0.455	0.567	-0.112
Effect of compressive end load on chord on Re under OPB of T=16mm	no	0.469	0.489	-0.020
	yes	0.275	0.346	-0.071
Effect of HSS range magnitude on Re for AX	HSS<200	0.11	0.260	-0.150
	HSS>=200	0.259	0.130	0.129
Effect of HSS range magnitude on Re for OPB	HSS<200	0.541	0.608	-0.067
	HSS>=200	0.273	0.194	0.079
Effect of HSS range magnitude on Re for IPB	HSS<200	0.567	1.511	-0.944
	HSS>=200	0.605	0.757	-0.152
Girth welded pipes OD=324mm and Thickness=12.7mm	-	0.04	0.042	-0.002

Comparison Zhang & Wintle table with collection of Zhang & Wintle database

Continuation of Table 2: Remaining life statistics for key variables (COV)

Variable	Condition compared	Report COV	Database COV	Difference of Report – Database COV
Assessment of stress ratio effect on Re	R=0	0.28	0.32	-0.043
	R=-1	0.21	0.53	-0.325
Effect of β on Re for T joints tested under OPB loading (D = 168 mm and T=6mm)	β=0.53	0.55	0.61	-0.055
	β=1	0.33	0.36	-0.027
Effect of β on Re for T joints tested under OPB loading (D = 457 mm and T=16mm)	β=0.25	0.85	0.92	-0.072
	β=1	0.32	0.56	-0.238
Effect of β on Re for T joints tested under AX loading (D = 457 mm and T=16mm)	β=0.5	0.28	0.28	0.003
	β=1	0.64	0.63	0.011
Effect of parameter τ on Re under axial loading	τ=0.55	0.64	0.75	-0.111
	τ=1	0.6	0.63	-0.030
Effect of parameter τ on Re under OPB loading (T=16mm)	τ=0.6	0.32	-	0.320
	τ=1	0.44	0.54	-0.103
Effect of chord wall thickness on Re under AX	T=6mm	0.76	0.67	0.087
	T=16mm	0.49	0.88	-0.386
	T=32mm	0.79	1.00	-0.209
	T=76mm	0.62	0.38	0.242
Effect of chord wall thickness on Re under OPB	T=6mm	0.45	0.47	-0.022
	T=16mm	0.88	0.91	-0.035
Effect of chord wall thickness on Re under IPB	T=6mm	0.69	0.73	-0.037
	T=16mm	0.61	0.98	-0.368
Effect of loading mode on Re for T joints with T=6 mm	AX	0.76	0.67	0.087
	OPB	0.45	0.47	-0.022
Effect of loading mode on Re for T joints with T=16 mm	AX	0.49	0.88	-0.386
	OPB	0.88	0.91	-0.035
Effect of loading mode on Re for K and KT joints with Thickness = 16 mm	AX	0.27	1.12	-0.855
	OPB	0.3	0.34	-0.042
Comparison of Re values between AX and IPB modes at T=6 mm (T joints)	AX	0.76	0.67	0.087
	IPB	0.69	0.73	-0.037
Comparison of Re values between AX and IPB modes at T=16 mm (T joints)	AX	0.49	0.88	-0.386
	IPB	0.61	0.98	-0.368
Comparison of Re valued between O and N for K and KT joints	OK and OKT joints	0.37	1.41	-1.037
	NK and NKT joints	0.37	0.52	-0.152

Variable	Condition compared	Report Sampl e size	Database Sample size	Difference of Report - Database
Comparison of Re valued between T and K/KT Joints with T=6 mm OPB	T joints	0.45	0.47	-0.022
	K and KT joints	0.58	0.48	0.097
Comparison of Re valued between T and K/KT Joints with T=16 mm OPB	T joints	0.88	0.91	-0.035
	K and KT joints	0.3	-	0.300
Comparison of Re values between T and Y joints under axial loading	T joints, T=16mm	0.49	1.12	-0.628
	Y joints, T=20mm	0.75	0.63	0.121
Mean Re values of X joints tested under AX and IPB	AX	0.44	0.42	0.021
	IPB	0.7	0.82	-0.115
Effect of PWHT on Re for specimens with chord thickness of 32mm tested under AX	As welded	0.79	0.91	-0.124
	PWHT	0.27	0.49	-0.218
Effect of PWHT on Re for specimens with chord thickness of 76mm tested under IPB	As welded	0.85	0.05	0.797
	PWHT	0.52	0.58	-0.057
Damilano - Comparison of Re values between stiffened and unstiffened Y joints	Unstiffened	0.78	0.82	-0.045
	Stiffened	0.42	0.96	-0.537
UKOSRP II - Comparison of Re values between stiffened and unstiffened Y joints	Unstiffened	0.64	0.00	0.640
	Flexible Ring	0.24	0.23	0.015
	Stiff ring	1.01	0.67	0.343
Comparison of weld profile effect on Re	Type A	0.03	0.06	-0.031
	Type B	0.15	0.22	-0.073
	Type C	0.47	0.65	-0.175
	Type D	0.56	0.90	-0.340
	Type E	0.34	0.40	-0.064
	Type F	0.93	1.18	-0.249
Effect of weld toe grinding on Re under OPB in seawater environment	As-welded, Seawater FC	0.29	0.42	-0.131
	Weld toe ground, Seawater FC	0.37	0.50	-0.131
	Weld toe ground, Seawater + CP	0.3	0.37	-0.067
Effect of environment on Re for K and KT joints under OPB	Air	0.58	0.42	0.162
	Seawater FC	0.12	0.14	-0.024
	Seawater + CP	0.54	0.77	-0.230
Effect of environment on Re for T joints with T=32mm under AX	Air	0.36	0.94	-0.576
	Seawater FC	-	0.43	-0.425
	Seawater + CP	0.71	1.33	-0.621

Variable	Condition compared	Report Sample size	Database Sample size	Difference of Report - Database
Variable amplitude effect on Re under AX at T=6.3mm	CA	0.76	0.75	0.009
	VA	0.6	0.62	-0.022
Variable amplitude effect on Re under AX at T=16mm	CA	0.49	0.62	-0.134
	VA	0.87	1.00	-0.133
Variable amplitude effect on Re under IPB at T=6.3mm	CA	0.69	0.73	-0.040
	VA	0.3	0.36	-0.061
Variable amplitude effect on Re under IPB at T=16mm	CA	0.61	0.63	-0.021
	VA	0.95	1.09	-0.141
Effect of compressive end load on chord on Re under AX of T=6mm	no	0.76	0.67	0.087
	yes	0.41	0.74	-0.328
Effect of compressive end load on chord on Re under AX of T=16mm	no	0.49	0.77	-0.279
	yes	0.34	0.46	-0.120
Effect of compressive end load on chord on Re under IPB of T=6mm	no	0.69	0.73	-0.037
	yes	0.76	0.73	0.030
Effect of compressive end load on chord on Re under IPB of T=16mm	no	0.61	0.98	-0.368
	yes	0.43	0.43	0.004
Effect of compressive end load on chord on Re under OPB of T=6mm	no	0.45	0.47	-0.022
	yes	0.33	0.41	-0.078
Effect of compressive end load on chord on Re under OPB of T=16mm	no	0.88	0.91	-0.035
	yes	0.41	0.52	-0.106
Effect of HSS range magnitude on Re for AX	HSS<200	0.28	0.81	-0.527
	HSS>=200	0.67	0.79	-0.120
Effect of HSS range magnitude on Re for OPB	HSS<200	0.88	0.93	-0.046
	HSS>=200	0.54	0.54	0.005
Effect of HSS range magnitude on Re for IPB	HSS<200	0.65	1.06	-0.412
	HSS>=200	0.77	0.60	0.167
Girth welded pipes OD=324mm and Thickness=12.7mm	-	0.46	0.49	-0.033