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Riser Installation by a J-Tube Pulling Method

H. S. Choi* and J. H. Jung*

Abstract

The analysis was carried out for a riser installation by a J-tube pulling method. The J-tube system components, mechanics of pull-in operation, and the theoretical background for the J-tube pull-in was investigated. A computer program was developed to calculate the pull-in force for a riser installation by a J-tube pulling method.

Key Words : J-tube Conduit, Riser, Offshore Pipeline, J-tube Pull Force

1. Introduction

The J-tube is a curved conduit which is attached to or built into a fixed offshore platform prior to its placement on site, to facilitate the subsequent installation of a riser onto the platform. A typical J-tube pull-in method is shown in Figure 1. The typical procedure of installation is to pass a cable from a winch sited on the platform deck, down through the J-tube and out to the lay-barge where it is attached to a pull-head on the end of the pipeline. The winch is used to pull the pipeline from the barge and up through the J-tube conduit. The use of J-tube provides significant commercial and technical advantages inherent in this method, the most important being no sub-sea connections between riser and pipeline and more effective use of barge time for continuous laying. Moreover, the use of J-tube provides a facility for the installation of risers at various times in the life of the production unit in a manner which can be incorporated into the initial design of the platform. In this study, the theories involved in the J-tube pull-in method was investigated and a computer program was developed to calculate the pull-in load for a riser installation.

2. J-Tube System Components

The J-tube conduit generally consists of a flared J-tube mouth, a large radius pipe bend to transition from the horizontal to the near vertical and a near vertical length of pipe which extends from the curved transition piece to an outlet located above water. Usually a messenger cable is installed inside the J-tube conduit for later use during the riser installation. Various components of a typical J-tube configuration are listed and described below :

J-Tube Conduit – J-tube conduit are normally fabricated and installed with platform. Thus, the conduit size must be determined during the jacket design. The diameter and wall thickness selected limit the size of the riser pipe and affect the pull force expected during the riser installation. The configuration of the conduit and in particular the radius of the lower bend must be selected such that it fits the structural dimensions of the jacket. The radius of this lower bend also determines the maximum bending strain imposed on the riser pipe during pull-in and influences pull forces. The orientation of the J-tube conduit defines the direction of pipeline approach to the platform and must be carefully selected to avoid interference with other facilities outlying the platform area.

J-Tube Mouth – The shape of the J-tube mouth will typically be "bell mouth" in order for it to serve as a guide for the pipe pull-head. The height and slope above the seabed affect bending stresses in the pipe span at the J-tube mouth exit.

Riser Pipe String – The planned riser pipe diameter, wall thickness, and grade must be considered in selecting the J-tube conduit size and its configuration. This string of pipe will normally have a special corrosion coating system. A vulcanized elastomer such as neoprene, is used to limit coating damage during the pull-in and to provide electrical isolation between the pipeline/riser and platform.

Pipeline Near J-Tube Mouth – The diameter, wall thickness, grade, and weight coating system for the pipe nearest the J-tube plays an important role as regards the force required the pipeline and the soil also affect the required pull force.

Electrical Isolation System – Most J-tube installations rely on the riser pipe corrosion coating system to provide electrical isolation from the platform. However, monolithic insulating couplings have also been used to electrically isolate the pipeline from the riser pipe string.

3. Mechanics of J-Tube Pull-in Operation

There are three distinct stages during the riser installation by a typical J-tube pull-in method.1), 2), 3) Three stages of pull-in and their definitions are illustrated in Figure 2.

Stage 1 – The initially straight riser encounters the curved walls of the J-tube and has to undergo bending to proceed further. The J-tube will commonly result in plastic straining of the riser pipe. The riser is bent by three-point loading condition with lengths l_1 and L

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* Department of Naval Architecture and Ocean Engineering, Pusan National University

between the contact points being dependent upon the J-tube bend radius R, the inside diameter of J-tube D and outside diameter of the riser d as shown in Figure (2a). Friction forces are induced at the contact points, the magnitudes of which are dependent upon the normal component of the contact forces and the coefficient of friction between the riser pipe and J-tube pipe. The test record shows the pull-in load to increase uniformly to a maximum value of P_I for stage I.

Stage II – The riser progresses through the bend with its shape being held in conformation with the walls of the J-tube. The relative position of the leading contact points and the pull-in load P_I, Remains constant until the pull-head of the riser emerges from the bend and enters the straight section of the J-tube as shown in Figure (2b). As this section of the J-tube is encountered, there is an elastic relaxation of the riser, and the pull-in load decreases accordingly to a minimum Stage II value P_{II}.

Stage III – As the riser enters the straight portion of the J-tube, it has a residual curvature resulting from the plastic deformation it has undergone. The residual curvature causes the pull-head eventually to contact the inner side of the J-tube. Subsequent progress may continue only if the riser is deflected in the oppsite sense as shown in Figure (2c). The extra work requirement results in a corresponding increase in the pull-in load which attains a maximum and thereafter constant value P_{III}.

4. Analysis of Pull-In Loads

The analysis developed below make use of the work of Walker and Davies.[3)] Simplifying assumptions are made, but in such a way as to ensure conservative estimation of the pull-in loads. Two important assumptions are that the stress-strain relationship is bi-linear and no account is taken of ovalisation of the riser cross section.

4.1 Moment-Curvature Relationship for Pipeline Riser

A quadrant of the riser cross-section is shown in Figure 3. If it is assumed plane sections remain plane and ω is the half-angle subtended at the centre of the cross-section by the plastically strained segments of the riser wall, then the resultant moment may be shown to be :

$$M = \left(d_m{}^2 t\sigma_0 / 2\right)\left[\sin\omega + \sec\left(\pi/2 - \omega\right)\right] \qquad (1)$$

where d_m is the mean diameter measured to the mid-wall of the riser.

When $\omega = \pi/2$, the moment is equal to the fully plastic moment, M ; and when $\omega = 0$, the moment is equal to the first-yield moment M_0.

ie

$$M_p = d_m{}^2 t\sigma_0$$

$$M_0 = (\pi/4)d_m{}^2 t\sigma_0 = (\pi/4)M_p \qquad (2)$$

A simple empirical relationship of moment-curvature is:

$$\bar{\varepsilon}/\varepsilon_0 = 1 + 2.25(\overline{M}/M_0 - 1) + 4.42\times10^5(\overline{M}/M_0 - 1)^9$$

$$,\ \text{if } \bar{\varepsilon}/\varepsilon_0 \succ 1 \qquad (3)$$

$$\bar{\varepsilon}/\varepsilon_0 = (4/\pi)(\overline{M}/M_p),\ \text{if } \bar{\varepsilon}/\varepsilon_0 \prec 1 \qquad (4)$$

The portion of the riser between contact points as it is pulled through the J-tube may be treated as a simple cantilever loaded into the elastic-plastic range, shown in Figure 4.

The rotation θ_t at the due to at the tip of the cantilever is:

$$\theta_t = \beta(\overline{M}L/2EI) = \beta(\overline{M}/M_p)(4\sigma_0/\pi E)(L/d) \qquad (5)$$

where $\overline{M}$ is the moment at the root of the cantilever and therefore represents the maximum moment at some point in the riser, and β is defined as

$$\beta = 2.25 - 2.5/k + 1.25/k^2 + 8.84\times10^4(k-1)^{10}/k^2 \qquad (6)$$

where, $k = \overline{M}/M_0 = 1.2732(\overline{M}/M_p)$

If the riser was perfectly elastic, the rotation would be where, $\overline{M}L/2EI$; hence β may be considered to be a 'plasticity correction factor'.

The deflection Δ_t at the end of the cantilever is:

$$\Delta_t = \alpha(\overline{M}L^2/3EI) = \alpha(\overline{M}/M_p)(8\sigma_0/3\pi E)(L^2/d) \qquad (7)$$

where

$$\alpha = 2.25 - \frac{1.875}{k} + \frac{0.625}{k^3} + \frac{1.31\times10^5(k-1)^{10}}{k^3} + \frac{1.21\times10^5(k-1)^{11}}{k^3}$$

in which α can be considered to be another 'plasticity correction factor'.

4.2 Stage I of the Pull-In

The pull-in load considered in this analysis is made up of two distinct components P_1, P_2 defined as:

P_1 - load required to deform the pipe plasticity

P_2 - load required to overcome the frictional resistance at the contact points between the riser and the J-tube.

Observations during all the tests revealed that the riser is subjected to a three-point loading condition, as shown in Figure 2(a); that is, ther are three contact positions at A, B and C. The riser is constrained to deform in accordance with the geometry of the J-tube, hence the deformation along the length L is:

$$\Delta_t = L\phi - (R./2 + D/2)\phi^2 - (D - d) \quad (8)$$

where ϕ is shown if Figure 2(a) and is the particular value of θ_t for the riser section between A and B.

Substituting for ϕ and Δ_t from equations (6) and (7), the length L can be culculated as

$$\frac{L}{d} = [(D/d - 1)/$$

$$\{(\beta - \frac{2\alpha}{3})(\frac{\overline{M}}{M_0})(\frac{\sigma_0}{E}) - (\frac{\beta\overline{M}}{M_0})^2(\frac{\sigma_0}{E})^2(\frac{R}{d} + \frac{D}{d})/2\}]^{\frac{1}{2}} \quad (9)$$

The length l_1 (refer Figure 2(a)) is obtained from the approximation to the geometry between points B and C.

Using equation (7), this leads to:

$$\frac{l_1}{d} = \left[\frac{(R/d + D/d)^2 - (R/d + 1)^2}{1 - (\alpha\overline{M}/M_0)(4\sigma_0/3E)(R/d + D/d)}\right]^{\frac{1}{2}} \quad (10)$$

The angle τ subtended at O (refer Figure 2(a)) by the leading length l_1 of the riser is simply

$$\tau = \sin^{-1}\left[\frac{l_1/d}{R/d + D/d}\right] \quad (11)$$

It is considered that the riser is deformed by forces which act normal to the J-tube walls and form couples with a moment at B equal to $\overline{M}$. As the riser is pulled through the J-tube, it is required to deform locally to the curvature of the J-tube. If the curvature of the J-tube is such that the material is strained plastically, there will be irreversible work done on the riser. A simple blance between the work required to pull the riser through the Stage I deformation and the energy of plastic deformation shows that the equivalent component P_1 of the pull-in load can be approximated by:

$$P_1 = \overline{M}/R_p \quad (12)$$

where R_p is the plastic radius of curvature given approximately by

$$d/R_p = d/R - 2\sigma_0/E \quad (13)$$

Physically, the componet P_1 can be considered as the load required to pull the riser if all the frictional effects are reduced to zero. If the material is not strained into the plastic regime the effect of elastic straining is ignored and $P_1 = 0$.

A similar level of approximation is adopted for the other component, P_2, of the pull-in load. Therefore the pull-in load for Stage I, P_I, is given by

$$P_I = P_1 + P_2 = \overline{M}/R_p + 2\mu\overline{M}(1/L + 1/l_1) \quad (14)$$

where μ is the coefficient of friction between riser and J-tube. This can be non-dimensionalised with respect to the tensile yield load of the riser P_0 ($= d_m t\sigma_0$) to give

$$\frac{P_I}{P_0} = \left(\frac{\overline{M}}{\pi M_P}\right)\left[\frac{d}{R} - \frac{2\sigma_0}{E} + 2\mu\left(\frac{d}{L} + \frac{d}{l_1}\right)\right] \quad (15)$$

4.3 Stage II of the Pull-In

As the riser pull-head enters the straight portion of the J-tube at the end of the bend, there will be a reduction in the curvature of the riser required for it to proceed through the J-tube. This reduction in curvature is accompanied by elastic relaxation of the riser. It is assumed that an average curvature comprising the contributions of the plastic and elastic deformations will exist between the leading contact points D and E. If δ is the relative deflection between the leading contact points, the compatibility with the J-tube geometry requires

$$\delta = l_2\gamma - (R/2 + D/2)\gamma^2 - (D - d) \quad (16)$$

where γ is the angle subtended by the contact points, as shown in Figure 2(b).

Following the assumption of a uniform radius of carvature, the length l_2 between the leading contact points is obtained from equation (16) as

$$\frac{l_2}{d} = \left[\frac{2C_1(D/d - 1)}{(2 - C_1/C_2) - (R/d + D/d)/C_1}\right]^{\frac{1}{2}} \quad (17)$$

where, $C_1 = (d/R - \sigma_0/E)^{-1}$

$C_2 = (d/R - 2\sigma_0/3E)^{-1}$

and for the situation where no plastic straining has occurred

$C_1 = R/2d$; $C_2 = 2R/3d$

The pull load is calculated using equation (15) with l_2 substituted for l_1 and with L being defined in equation (9).

4.4 Stage III of the Pull-In

The riser progress into the straight portion of the J-tube with a residual curvature. As shown in Figure 2(c), the deflection imposed on the riser between E and F, to maintain conformity with the straight J-tube geometry, is Δ which is given by

$$\overline{\Delta} = (l_3)^2/2R_p - (D - d) \quad (18)$$

the deformation of the riser acting as a cantilever between E and F as given by equation (7) is

$$\overline{\Delta}/d = (\alpha\overline{M}/M_p)(8\sigma_0/3\pi E)(l_3/d)^2 \quad (19)$$

The pull load, P', required for the straightening process in Stage III is given by

$$P'/P_0 = (2\mu/\pi)(\overline{M}/M_p)(d/l_3) \quad (20)$$

The value of $\overline{M}$ and l_3 are obtained from the solution of equations (18) and (19) to give the maximum values of P'.

The total Stage III pull-in load is given by

$$P_{III}/P_0 = P_{II}/P_0 + (2\mu d/\pi M_p)(\overline{M}/l_3)\max \quad (21)$$

4.5 Total Pull-In Load

The Total pull-in load can be calculated as:

$$P_T = (P_I + T)EXP(\mu_c \psi) + W \qquad (22)$$

where:

P_T : the total pull-in force;
T : back tension applied to pipeline
μ_c : coefficient of friction between pull-in cable and J-tube
ψ : angle of contact between pull-in cable and J-tube
W : Weight of suspended pull-in cable and riser

5. Computer Program and Calculations

A Microsoft Excel program that calculates the maximum pull-in forces during the three stages were developed. Many calculations were performed and the calculation results were compared with those of American Gas association.[3)]

5.1 Input Data

5.1.1 Riser Pipe Properties

Riser pipe outside diameter, d
Riser pipe wall thickness, t
Riser pipe yield strength, S
Riser pipe modulus of elasticity, E (default = 29000 ksi)
Riser pipe coating thickness, tc
Riser pipe coating density, dc
Friction coefficient between riser and J-tube, f_r (default = 0.3)

5.1.2 Pulling Cable Properties

Cable size
Friction coefficient between cable and J-tube, f_c (default = 0.4)
Pull winch elevation (ft)

5.1.3 J-Tube Conduit Properties

Bend J-tube outside diameter, D_j
Bend J-tube wall thickness, t_j
Vertical tube outside diameter, D_{jv}
Vertical tube wall thickness, t_{jv}
Entry tangent length
Entry tangent slope (deg)
J-tube bend radius, Rcl
J-tube bend angle, *a* (deg) (acute angle less than 90 degrees)
J-tube exit elevation
J-tube entrance height-off-bottom, hob

5.1.4 Laybarge tension and water depth

Hold-back Tension at Touchdown, Th
Length of Riser on Sea Bottom, Lob
Riser Pipe to Soil Friction Coefficient, fs (default=0.4)
Water depth, h (ft)

5.2 Output Data

5.2.1 Calculation for Pulling Force

Median pipe diameter, dm
ID of J-tube conduit, D
J-tube inside ID radius, R (ft)
Bi-axial yield stress, Yo (ksi)
Fully plastic pipe moment, Mp
Riser pipe strain, e
Yield moment, Mo
Yield strain, eo
Elastic pipe stiffness, EI
Yield diameter for riser, do
Half-angle of yield circle, w (rad)
Riser bending moment, M
M/Mo bending moment ratio, k
M/Mp bending moment ratio, $k*\pi/4$
Cantilever deflection plasticity factor, α
Cantilever slope plasticity factor, β
Cantilever deflection moment ratio, α*M/Mp
Cantilever slope moment ratio, β*M/Mp
J-tube inside radius bend ratio, R/d
Gap ratio between bend ID and pipe OD, D/d
Gap ratio between vertical tube ID and pipe OD, D/d
Axial yield force, Po (kips)
Residual radius-curvature ratio, Rp/d
Pull force at pullhead entry (kips)
Pullhead length into J-tube (ft)

5.2.2 Stage 1 Calculation

Length ratio, $l_1/d = 1/K$
Maximum length ratio, L/d
Minimum entry length ratio, Le/d
Available entry length ratio, Lav/d
Length ratio if Lav/d < Le/d
True length ratio, L/d
Pull force ratio, PI/Po
Deformation pull force , PI (kips)
Deformation deflection, $\Delta t/d(L)$
Deformation deflection, $\Delta t/d(l_1)$
Angle for stage 1, ϕ (degrees)
Angle for stage 1, τ (degrees)
Pullhead elevation (ft)
Pullhead length into J-tube (ft)
Dead weight pull force (kips)
Pull force at stage 1 (kips)

5.2.3 Stage 2 Calculation

Constant for stage 2, C1
Constant for stage 2, C2
Length ratio, $l_2/d = 1/K$
Pull force ratio, PII/Po
Deformation pull force, PII (kips)
Deformation deflection, $\Delta t/d(l_2)$

Angle, γ (degrees)
Stage 2 pullhead elevation (ft)
Stage 2 pullhead length into J-tube (ft)
Stage 2 dead weight pull force (kips)
Pull force at stage 2 (kips)

5.2.4 Stage 3 Calculation

Moment ratio for P'/Pl_max, M/Mp
Length ratio for P'/Po_max , l_3/d
P'/Po_max
Deformation pull force, PIII/Po
Deformation pull force , PIII (kips)
Initial stage 3 pullhead elevation (ft)
Pullhead length into J-tube (ft)
Initial stage 3 dead weight pull force (kips)
Initial pull force at stage 3 (kips)
Final stage 3 pullhead elevation (ft)
Final pull-head length into J-tube (ft)
Final stage 3 dead weight pull force (kips)
Final pull force at stage 3 (kips)

5.3 Calculations

Various calculations were performed and the results are presented in the Figure 5 and Figure 6. In Figures 5 and 6, the results are compared with the calculations of the AGA. Our calculations are generally 30% to 50% higher than the AGA. Field data should used to verify the calculations.

A sample calculation is attached in Appendix.

References

1) AGA. "Pipeline Riser System Design and Application Guide", Project PR-178-622, Final Report by Brown Root USA, Inc.
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3) Walker, A.C. and Davies, P. (1983). "A Design Bases for the J-tube Method of Riser Installation", J. of Energy Resources Technology, vol.105 pp263-270.

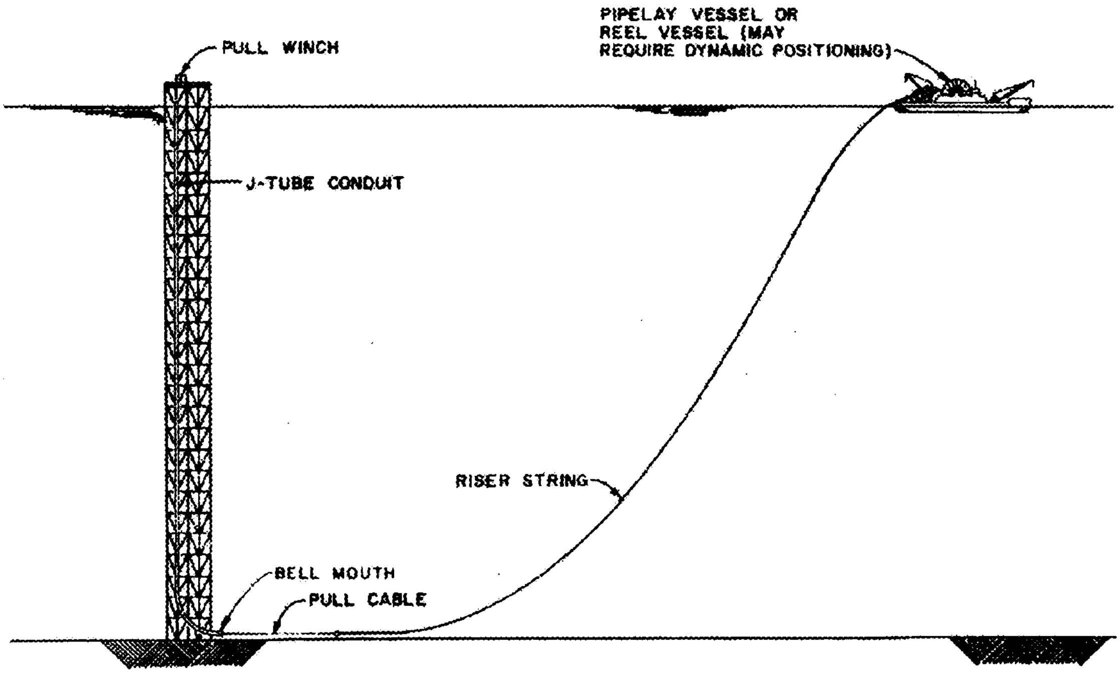

Figure 1. Typical Riser Pull-in Operation

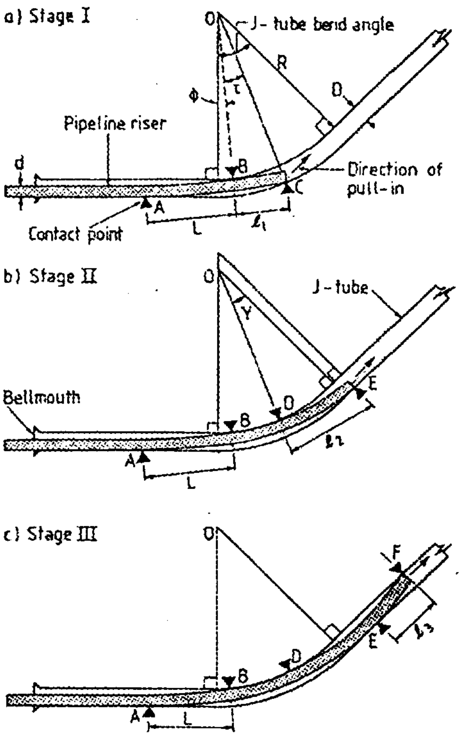

Figure 2. Stages of Pull-In

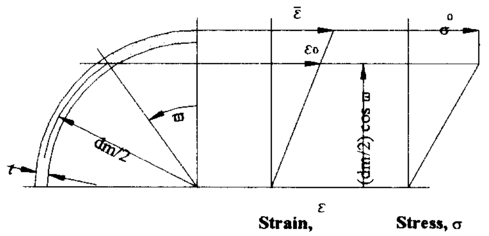

Figure 3. Quadrant of Riser Cross Section

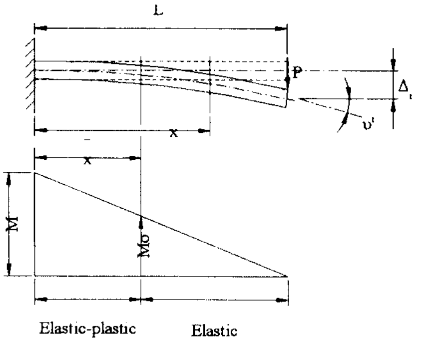

Figure 4. Cantilever Model of Leading Length of Riser

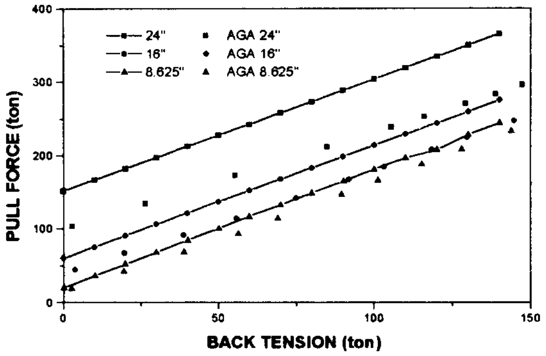

Figure 5. J-tube Pull Force vs. Back Tension

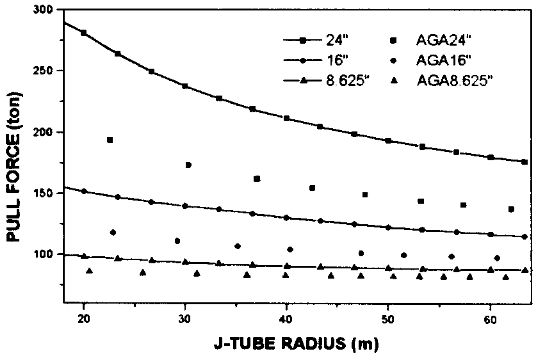

Figure 6. J-tube Pull Force vs. J-tube Radius

APPENDIX : Sample Calculation

PNU Ocean Engineering Lab.

J-TUBE PULL-IN FORCE ESTIMATION

Client :	Your Client
Job Number :	HC-007
Project Description :	Example case
Engineer :	HC

INPUT DATA

Riser Pipe Properties

Outside Diameter, d (in)	=	24.000
Wall Thickness, t (in)	=	1.000
Yield Strength, S (ksi)	=	42
Modulus of Elasticity, E (ksi)	=	29000
Coating Thickness, tc (in)	=	0.000
Coating Density, dc (pcf)	=	100.000
Pipe to J-tube Friction Coefficient, fr	=	0.300
Maximum Moment Capacity (in-kips)	=	24192.000
Steel Section Area (in^2)	=	72.257
Submerged Weight, Wr (kpf)	=	0.045

Pulling Cable Properties

Cable Size (in)	=	2 1/2
Cable to J-tube Friction Coefficient, fc	=	0.300
Pull Winch Elevation (ft)	=	120.000
Submerged Weight, Wc (kpf)	=	0.012

J-Tube Conduit Properties

Bend Tube Outside Diameter, Dj (in)	=	36.000
Bend Tube Wall Thickness, tj (in)	=	1.000
Vertical Tube Outside Diameter, Djv (in)	=	36.000
Vertical Tube Wall Thickness, tjv (in)	=	1.000
Entry Tangent Length (ft)	=	10.00
Entry Tangent Slope (deg), - ^H, + vH	=	0
Bend Radius at Centerline, Rcl (ft)	=	100
Bend Angle, a (deg)	=	90
Exit Elevation (ft)	=	120
J-tube Entrance Height-Off-Bottom, hob (ft)	=	0.0

Laybarge Tensions and Water Depth

Hold-back Tension at Touchdown, Th (kips)	=	120.00
Length of Riser on Sea Bottom, Lob (ft)	=	50
Riser Pipe to Soil Friction Coefficient, fs	=	0.500
Water Depth, h (ft)	=	100

OUTPUT DATA

Calculations for Pulling Force

Median Pipe Diameter, dm (in)	=	23.000
ID of J-tube Conduit, D (in)	=	34.000
J-tube Inside ID Radius, R (ft)	=	98.583
Bi-Axial Yield Stress, Yo (ksi)	=	45.732
Fully Plastic Pipe Moment, Mp (in-kips)	=	24192.000
Riser Pipe Strain, e (in/in)	=	0.010042
Yield Moment, Mo (in-kips)	=	19000.35
Yield Strain, eo (in/in)	=	0.001577
Elastic Pipe Stiffness, EI (kip-in^2)	=	1.45E+08
Yield Diameter for Riser, do (in)	=	3.767
Half-Angle of Yield Circ., w (rad)	=	1.41
Riser Bending Moment, M (in-kips)	=	24086.23
M/Mo Bending Moment Ratio = k	=	1.2677
M/Mp Bending Moment Ratio = (Pi/4)*k	=	0.9956
Cantilever Def. Plasticity Factor, alpha(k)	=	1.2292
Cantilever Slope Plasticity Factor, beta(k)	=	1.1596
Cantilever Deflec Moment Ratio, alpha*M/Mp	=	1.2238
Cantilever Slope Moment Ratio, beta*M/Mp	=	1.1545
Jtube Inside Radius Bend Ratio, R/d	=	49.29
Gap Ratio, Bend ID / Pipe OD, D/d	=	1.4167
Gap Ratio, Vert Tube ID / Pipe OD, D/d	=	1.4167
Axial Yield Force, Po (kips)	=	3304.41
Residual Radius-Curvature Ratio, Rp/d	=	5.84E+01
Angle for Stage 1, Phe (degrees)	=	0.94
Angle for Stage 1, Tau (degrees)	=	8.05
Constant for Stage 2, C1	=	53.45
Constant for Stage 2, C2	=	51.99

Pullhead Entry to J-tube

Pull Force at Pullhead Entry (kips)	=	193.40
Pullhead Length into J-tube (feet)	=	0.00

Summary of Results

Pullhead Entry Pull Force (kips)	=	193.40
Stage 1 Maximum Pull Force (kips)	=	486.22
Stage 2 Maximum Pull Force (kips)	=	291.53
Stage 3 Maximum Pull Force (kips)	=	429.92

Stage 1	Length Ratio, $l_1/d = 1/K$	=	7.10
	Maximum Length Ratio, L/d	=	27.59
	Minimum Entry Length Ratio, Le/d	=	26.77
	Available Entry Length Ratio, Lav/d	=	5.00
	Length Ratio if Lav/d < Le/d	=	7.10
	True Length Ratio, L/d	=	7.10
	Pull Force Ratio, PI/Po	=	5.90E-02
	Deformation Pull Force, PI (kips)	=	194.84
	Deformation Deflection, Delta_t/d(L)	=	8.27E-02
	Deformation Deflection, Delta_t/d(l_1)	=	8.27E-02
	Pullhead Elevation (ft)	=	-84.36
	Pullhead Length into J-tube (feet)	=	25.70
	Dead Weight Pull Force (kips)	=	3.36
	Pull Force, Stage 1 (kips)	**=**	**486.22**
Stage 2	Length Ratio, $l_2/d = 1/K$	=	29.95
	Pull Force Ratio, PII/Po	=	1.87E-02
	Deformation Pull Force, PII (kips)	=	61.70
	Deformation Deflection, Delta_t/d(l_2)	=	1.47E+00
	Angle, Gamma (degrees)	=	3.98
	Stage 2 Pullhead Elevation (ft)	=	-1.42
	Stg2 Pullhead Length into J-tube (feet)	=	167.08
	Stage2, Dead Weight Pull Force (kips)	=	6.11
	Pull Force, Stage 2 (kips)	**=**	**291.53**
Stage 3	Moment Ratio for P'/Po_max, Mj/Mp	=	1.0011
	Length Ratio for P'/Po_max, l_3/d	=	7.78
	P'/Po_max	=	2.46E-02
	Deformation Pull Force, PIII/Po	=	0.0433
	Deformation Pull Force, PIII (kips)	=	142.95
	Initial Stage 3 Pullhead Elevation (ft)	=	21.91
	Pullhead Length into J-tube (feet)	=	190.41
	Init Stg3 Dead Weight Pull Force (kips)	=	6.89
	Initial Pull Force, Stage 3 (kips)	**=**	**429.92**
	Final Stage 3 Pullhead Elevation (ft)	=	120.00
	Final Pullhead Length into J-tube (feet)	=	288.50
	Final Stg3 Dead Weight Pull Force (kips)	=	10.14
	Final Pull Force, Stage 3 (kips)	**=**	**422.42**