SEAL-LOCK XD TUBING
3.500 OD 12.70 lb/ft P110 CAL IV
Extrapolation
Connection Brief

Industry Standard Connection Qualification Testing and Evaluation

API RP 5C5:2017 4th ed.

Hunting Energy Services

Connection Technology Division

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SEAL-LOCK XD is a threaded and coupled premium connection designed to provide internal and external pressure integrity under extreme loads. SLXD utilizes a negative load-flank thread form, advanced connection geometry, and a metal-to-metal seal to provide performance ratings that equal or exceed pipe body ratings in tension, compression, internal and external pressure. SLXD is designed and tested for HPHT wells and critical service applications.

Experimental testing and analytical evaluation of these loads are essential to validating a connection performance envelope. Hunting Energy Service Connection Technology Division has standardized on API RP 5C5 Fourth Edition, January 2017 for the experimental testing and validation of tubing connection performance.

As experimental testing in accordance with API RP 5C5 is costly and time consuming, product line validation and extrapolation/interpolation of connection designs fully tested have significant benefits. API recognizes that full-scale physical testing on every diameter, mass, and grade within a product line is not practical and not necessary to define connection performance. Hunting Energy Service Connection Technology Division has established guidelines for product line validation through the interpolation and extrapolation of completed full scale physical connection testing compliant with API RP 5C5 Annex F. Refer to the HES "Premium Connection Product Line Validation and Extrapolation Connection Brief" for an example of these guidelines.

The foundation for the SEAL-LOCK XD tubing product line validation is centered on the full scale API RP 5C5 4ed: 2017 CAL IV Qualification testing of 3.500 12.70 lb/ft on API P110 material. The 3.500 SLXD connections are fully interchangeable from 12.70 lb/ft (.375" wt) down through 9.20 lb/ft (.254" wt). The critical dimensions including thread geometry, seal geometry, and connection interferences are identical. Other critical dimension such as the pipe body to shoulder area ratio are parametrically scaled to the wall thickness. The 2.875 SLXD connections are also fully interchangeable from the 8.60 lb/ft (.308" wt) down through the 6.40 lb/ft (.217" wt). As the SLXD product line incorporates a parametric design methodology, the 2.875 and 3.500 connections share many features that are identical while the remaining are parametrically scaled to the wall thickness or diameter of the tube. Refer to Table 1 for the product design criteria elements and the comparison to the 3.500 12.70 lb/ft connection. The significant amount of geometric similarities makes these connections ideal for extrapolating the CAL IV validation testing results.

To extrapolate these testing results, Finite Element Analysis (FEA) was completed on the 3.500 12.70 and 9.20 lb/ft as well as the 2.875 8.60 and 6.40 lb/ft sizes to confirm the consistency of the galling tendency, sealing performance and structural integrity. Key parameters such as the actual material strengths, material properties, and friction factors from the 3.500 12.70 lb/ft CAL IV validation were incorporated into the FEA to bound the analysis. Structural integrity of the connections can be displayed from the VME stress plots of the connections. Galling tendency of the seal can be described by the maximum seal contact stress at the fully made up position. Seal performance can be evaluated by the seal energy and the maximum contact stress. The seal energy and contact stress were normalized by the applied pressure for comparison of the different weights, sizes and applied loads. Refer to Figure 1 and Tables 2, 3, and 4 for the VME Stress Plots, the contact stress at MU, the normalized seal energy, and the normalized seal contact stress.

Concluding the FEA, the products show remarkable consistency. The VME Stress plots exhibit similar stress concentrations with only the integral shoulder as the highly stressed feature. The low maximum contact stress at the made up position for all of the connections show the risk for galling tendency is the same or less than the validation testing. The normalized seal energy and contact stress plots show the seal performance is equivalent or greater than the validated product. FEA confirms the extrapolation of the 3.500 12.70 lb/ft API RP 5C5 4ed:

2017 CAL IV Qualification testing can be extended through the 3.500 9.20 lb/ft as well as the 2.875 8.60 lb/ft through the 6.40 lb/ft SLXD connections.

A.1.1 Connection Identification	**Seal Lock XD**			
Product Description	Size, Weight	Wall Thickness	Size, Weight	Wall Thickness
Threaded & Coupled Premium Connection	**2.875 6.40- 8.60**	**0.217- .308**	**3.500 9.20- 12.70**	**0.254- .375**
Connection Assessment Level	**API RP 5C5:2017 CAL IV**			
A.1.2 Connection Geometry	**Coupled Connection**			
A.1.5 Connection Manufacturing Specifications	**SEAL-LOCK XD SPECIFICATION MANUAL REV 005**			
Process Control Plan No.	**HCTD-QPP-RND-002**			
Pin Drawing No.	**M09731 REV NR**		**M09434 REV A**	
Box Drawing No.	**M09732 REV NR**		**M09435 REV NR**	
Pin Thread Drawing No.	**M08097-0008**			
Box Thread Drawing No.	**M08098-0008**			
Pin Surface Treatment Specification No.	**As Machined**			
Box Surface Treatment Specification No.	**PHOSPHATE COATING/PHOS REV 007**			
Gauge Calibration Procedure No.	**Seal Lock XD Gaging Procedures: Thread Element Gage Calibration R0**			
Gauging and Inspection Procedure No.	**SEAL-LOCK XD PIN/BOX Inspection Procedure REV 000**			
Seal Ring Inspection Procedure No.	**N/A**			
Swage/Stress-relief Procedure No.	**FORMED REV 000 and Stress Relieve REV 004**			
First/Last Article Procedure No.	**SLXD PIN INSP REV 000/SLXD BOX INSP REV 000**			
A.1.6 Connection Field/Mill Assembly and Field Repair Procedures				
Coupling/Accessory Makeup Procedure No.	**SLXD Field Running and Handling Procedure REV 000**			
Connection Field Running Procedure No.	**SLXD Field Running and Handling Procedure REV 000**			
Connection Field Repair Procedure No.	**SLXD Visual Thread Inspection Procedure REV 000**			
Thread Compound	**BOL 72733 & Banner Moli-G Lube**			

Product Design Criteria Elements	**2.875 6.40 SLXD**		**2.875 8.60 SLXD**		**3.500 9.20 SLXD**		**3.500 12.70 SLXD**	
Threaded and Coupled Premium Connection	Size, Weight	Wall	Size, Weight	Wall	Size, Weight	Wall	Size, Weight	Wall
	2.875 6.40	**0.217**	**2.875 8.60**	**0.308**	**3.500 9.20**	**0.254**	**3.500 12.70**	**0.375**
Lead	**N/C**		**N/C**		**N/C**		**N/C**	
Taper	**N/C**		**N/C**		**N/C**		**N/C**	
Thread Height	**N/C**		**N/C**		**N/C**		**N/C**	
Thread Form	**N/C**		**N/C**		**N/C**		**N/C**	
Torque Shoulder Angle / Shoulder to Pipe Body Ratio	**N/C / 51.6%**		**N/C / 60.5%**		**N/C / 61.5%**		**N/C / 69.6%**	
Seal Taper	**N/C**		**N/C**		**N/C**		**N/C**	
Seal Lengths	**N/C**		**N/C**		**N/C**		**N/C**	
Pin Nose Length	**N/C**		**N/C**		**N/C**		**N/C**	
Distance Between Face of Pin Nose to Thread Start	**N/C**		**N/C**		**N/C**		**N/C**	
Thread Interference	**N/C**		**N/C**		**N/C**		**N/C**	
Primary Seal Interference	**N/C**		**N/C**		**N/C**		**N/C**	
Pin Seal Area to Pipe Body Area Ratio	**71.25%**		**74.74%**		**72.91%**		**77.50%**	
Coupling OD / SC OD	**3.500 / 3.268**		**3.500 / 3.397**		**4.250 / 3.960**		**4.250 / 4.132**	
Critical Cross Section Area Box to Pipe Body Area Ratio	**168%**		**123%**		**172%**		**121%**	
Distance from Pin Nose to Centerline of Seal.	**N/C**		**N/C**		**N/C**		**N/C**	

Table 1: Product Design Criteria Elements

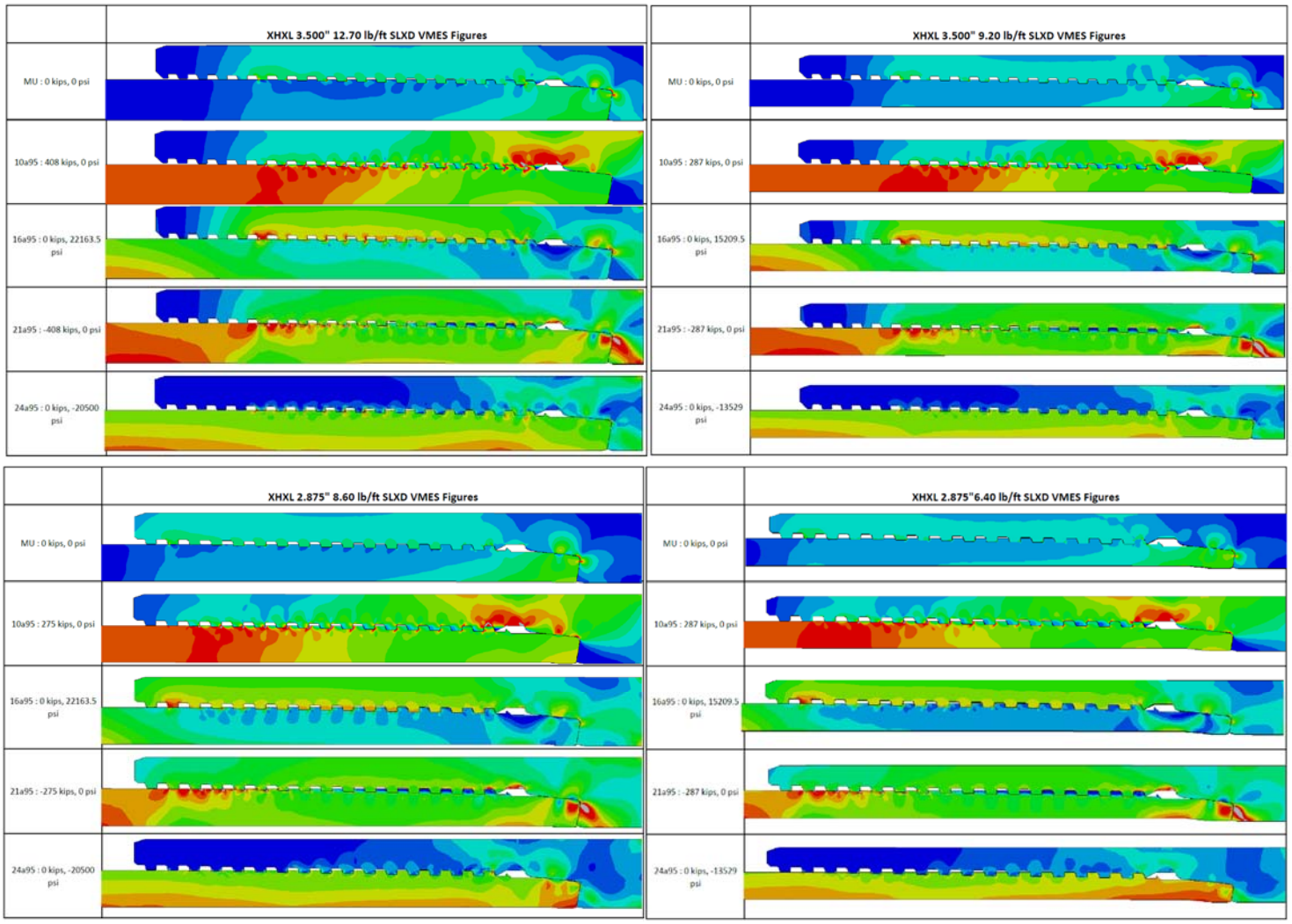

Figure 1: FEA VME Stress Plots

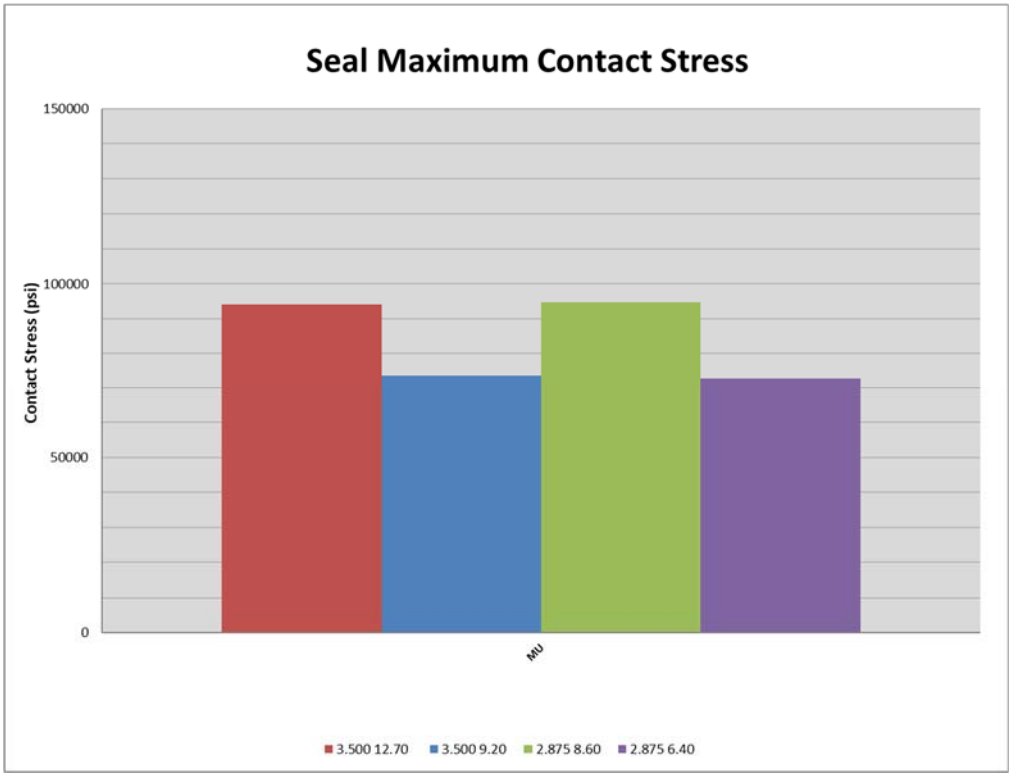

Table 2: MU Contact Stress

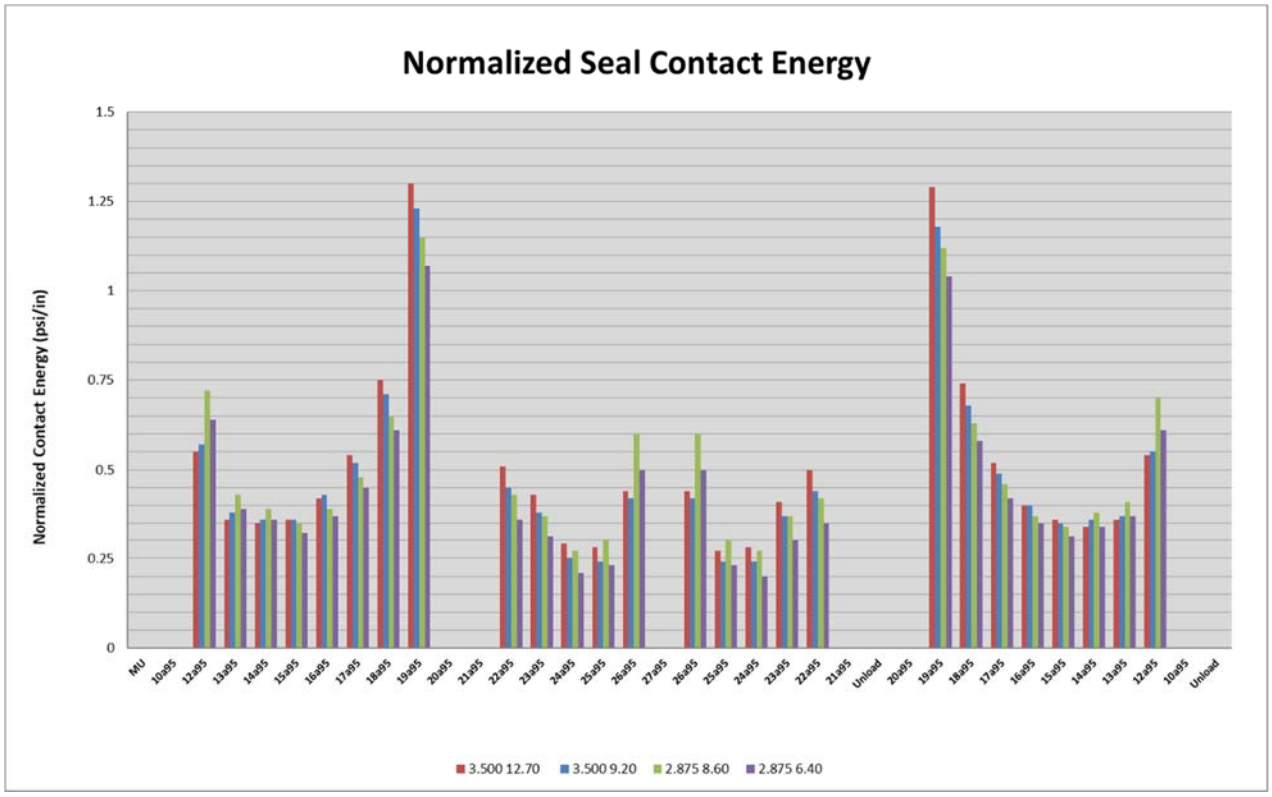

Table 3: Normalized Seal Contact Energy

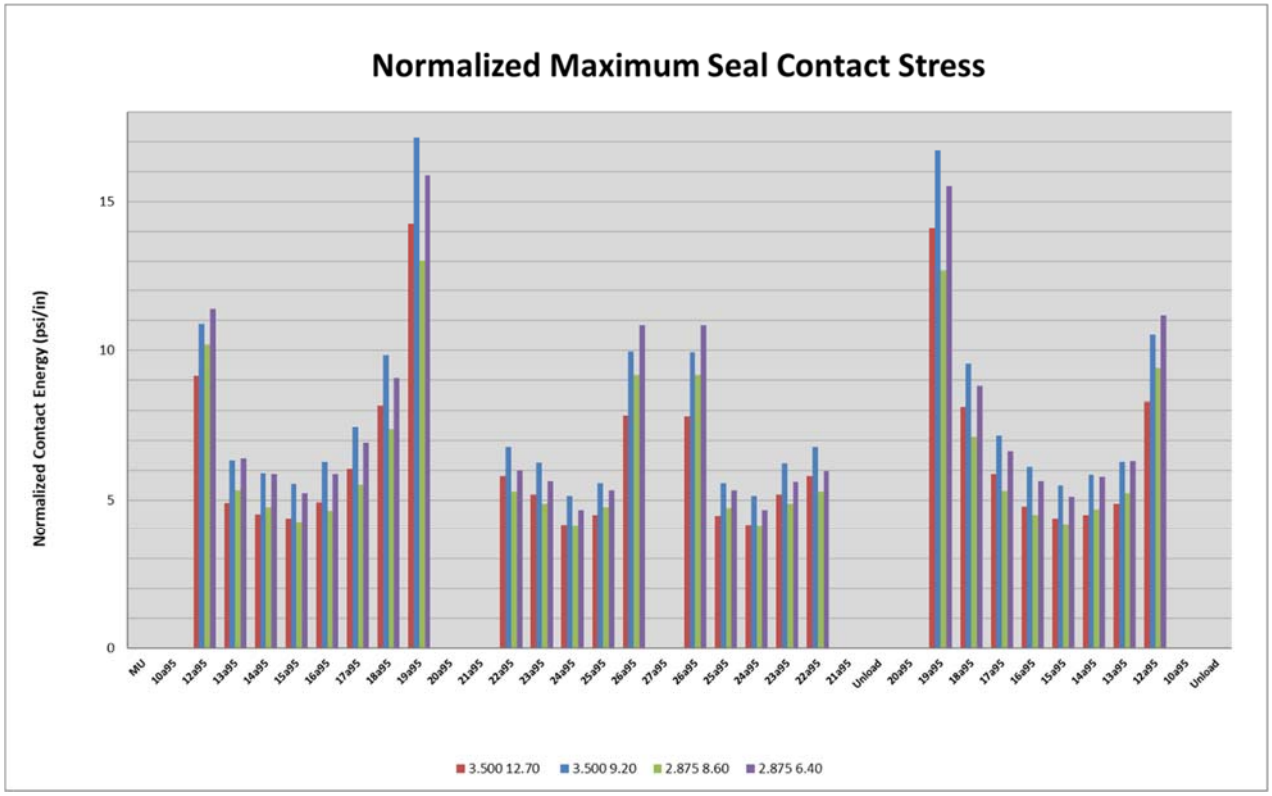

Table 4: Normalized Seal Contact Stress