Work Item Number	3092
Title of Work Item	Clarify Connection Evaluation Envelope for API RP 5C5
Ballot Revision Level	01
Type of Ballot (Initial, Comment, Comment resolution (reference API ballot#), 1st Re-ballot, 2nd Re-ballot, etc.)	Initial
Submitter Name(s)	Matthew Manuel
API Document Modified	API RP 5C5 4th ed.
Impacted Documents	
Revision Key	Current API document in black, Deletions in red strikethrough ~~remove~~, Additions in blue underlined <u>add</u>

Work Item Charge: Clarify the use of the connection evaluation envelope term and remove the ambiguity around the CEE from the document.

Ballot Rationale: Connection Evaluation Envelope (CEE)" is difficult to understand and seems to have a circular definition in 5C5.

The seemingly circular definition and overall vagueness in what the CEE is leads to misunderstandings around testing and connection performance properties. It also makes it difficult to use and implement the document.

Ballot Text:

3.3. Symbols

For the purposes of this document, the following symbols apply.

A^a cycles in TS-A at ambient temperature using gas for internal pressure and liquid for external pressure; for CAL I, liquid may be used for internal pressure

A^e cycles in TS-A at 356 °F (180 °C) for CAL III and CAL IV using gas for internal pressure and an appropriate liquid for external pressure

A_p nominal or average pipe body cross-section area; based on D and d for nominal, D_{avg} and d_{avg} for average

B^a cycles in TS-B, without bending, at ambient temperature using gas for CAL II through CAL IV; for CAL I, liquid may be used for internal pressure

B^a_b cycles in TS-B, with bending, at ambient temperature using gas for CAL II through CAL IV; for CAL I, liquid may be used for internal pressure

B^e_b cycles in TS-B, with bending, using gas at 356 °F (180 °C) for CAL III and CAL IV, or at 275 °F (135 °C) for CAL II

C compressive axial force

CEE^a*c* connection evaluation envelope compression at zero pressure at ambient temperature

CEE$^a F_a$ connection evaluation envelope axial load for the specified load point in Table 7 at ambient temperature

CEE$^a p_i$ connection evaluation envelope internal pressure at the specified CEE axial load for the specified load point in Table 7 at ambient temperature

CEE$^a p_o$ connection evaluation envelope external pressure at the specified CEE axial load for the specified load point in Table 7 at ambient temperature

CEE^a*t* connection evaluation envelope tension at zero pressure at ambient temperature

CEE$^e F_a$ connection evaluation envelope axial load for the specified load point in Table 7 at elevated temperature

CEE$^e p_i$ connection evaluation envelope internal pressure at the specified CEE axial load for the specified load point in Table 7 at elevated temperature

CEE$^e p_o$ connection evaluation envelope external pressure at the specified CEE axial load for the specified load point in Table 7 at elevated temperature

D API specified (nominal for non-API pipe) pipe OD

4.3 Connection Specification Sheet and Test Specimen Datasheet

Prior to beginning a test, the manufacturer shall provide a test plan. The test plan shall contain a connection specification sheet stating the intended assessment level to which test is performed, its geometry, and a connection datasheet stating the claimed minimum performance properties in terms of tension, compression, internal pressure, external pressure, bending, and torque based on minimum API pipe body performance properties for specified minimum material yield strength, specified OD, specified wall, and minimum wall (see Table A.1 for the connection specification sheet). The manufacturer shall provide a drawing representative of the cross-sectional area of the connection and documentation detailing the specifications, processes, and procedures required for the complete manufacture and inspection of the connection. The manufacturer shall provide the connection makeup parameters and repair procedures. Additionally, the manufacturer shall

identify any specific pipe body attributes (examples include 90 % minimum specified wall, high collapse, or controlled yield strength) that are required for the connection being evaluated.

For each test specimen, the manufacturer shall provide a test specimen datasheet. For each test specimen**,** the manufacturer shall provide the following plots in two-dimensional graphical form for both ambient and elevated temperature testing.

a) Pipe body reference envelope (VME plot with appropriate collapse curves).

b) CEE (polygon or other form, presented on same axes and scale as the pipe body reference envelope).

c) TLE.

The manufacturer's method of calculation should be used to derive the CEE. The CEE plot shall include the required CEE points specified in Table 7. Performance data may be used to determine the CEE. The TLE shall be bi-axially scaled as a percentage (80 %, 90 %, 95 %, or 100 %, whichever applies) of the CEE, shall include the required load points specified in Table 7, and shall be used to calculate the test load schedules.

Table 7—Load Point Definitions

Load Point	Test Series			Connection Evaluation Envelope (CEE)		Test Load Envelope (TLE)		Bend	Temp	Test Level
	A	B	C	Axial Point F_a	(1)Pressure Point p_i or p_o	Axial Load F_a	Pressure Load p_i or p_o			
Zero	•	•	•	0	0	0	0		Amb	All
1_a80		•		~~min(Ft^a,~~$CEE^a t$~~)~~	0	0.67 x LP 1_a80 CEE^aF_a	0		Amb	
2_a80		•				0.80 x LP 4a80 CEE^aF_a	0.25 x 0.80 x LP 4_a80 CEE^ap_i		Amb	
3_a80		•				0.80 x LP 4_a80 CEE^aF_a	0.50 x 0.80 x LP 4_a80 CEE^ap_i		Amb	
4_a80		•		0.67/0.80 x ~~min(Ft^a,~~$CEE^a t$~~)~~	100% CEE^ap_i	0.80 x LP 4_a80 CEE^aF_a	0.80 x LP 4_a80 CEE^ap_i		Amb	
5_a80		•		F_{CEPL}	100% CEE^ap_i	0.80 x LP 5_a80 CEE^aF_a	0.80 x LP 5_a80 CEE^ap_i		Amb	80%
6_a80		•		0	100% CEE^ap_i	0	0.80 x LP 6_a80 CEE^ap_i		Amb	
7_a80		•		0.50/0.80 x ~~min(Fc^a,~~$CEE^a c$~~)~~	100% CEE^ap_i	0.80 x LP 7_a80 CEE^aF_a	0.80 x LP 7_a80 CEE^ap_i		Amb	
8_a80		•				0.80 x LP 7_a80 CEE^aF_a	0.50 x 0.80 x LP 7_a80 CEE^ap_i		Amb	
9_a80		•		~~min(Fc^a,~~$CEE^a c$~~)~~	0	0.50 x LP 9_a80 CEE^aF_a	0		Amb	
10_a95	•	•		~~min(Ft^a,~~$CEE^a t$~~)~~	0	0.90 x LP 10_a95 CEE^aF_a	0		Amb	
11_a95		•				0.95 x LP 13_a95 CEE^aF_a	0.25 x 0.95 x LP 13_a95 CEE^ap_i		Amb	
12_a95	•	•				0.95 x LP 13_a95 CEE^aF_a	0.50 x 0.95 x LP 13_a95 CEE^ap_i		Amb	
13_a95	•	•		0.90/0.95 x ~~min(Ft^a,~~$CEE^a t$~~)~~	100% CEE^ap_i	0.95 x LP 13_a95 CEE^aF_a	0.95 x LP 13_a95 CEE^ap_i	Yes	Amb	
14_a95	•	•		0.80/0.95 x ~~min(Ft^a,~~$CEE^a t$~~)~~	100% CEE^ap_i	0.95 x LP 14_a95 CEE^aF_a	0.95 x LP 14_a95 CEE^ap_i	Yes	Amb	
15_a95	•	•		F_{CEPL}	100% CEE^ap_i	0.95 x LP 15_a95 CEE^aF_a	0.95 x LP 15_a95 CEE^ap_i		Amb	95%
16_a95	•	•		0	100% CEE^ap_i	0	0.95 x LP 16_a95 CEE^ap_i	Yes	Amb	
17_a95	•	•		0.25/0.95 x ~~min(Fc^a,~~$CEE^a c$~~)~~	100% CEE^ap_i	0.95 x LP 17_a95 CEE^aF_a	0.95 x LP 17_a95 CEE^ap_i	Yes	Amb	
18_a95	•	•		0.50/0.95 x ~~min(Fc^a,~~$CEE^a c$~~)~~	100% CEE^ap_i	0.95 x LP 18_a95 CEE^aF_a	0.95 x LP 18_a95 CEE^ap_i	Yes	Amb	
19_a95	•	•		0.75/0.95 x ~~min(Fc^a,~~$CEE^a c$~~)~~	100% CEE^ap_i	0.95 x LP 19_a95 CEE^aF_a	0.95 x LP 19_a95 CEE^ap_i	Yes	Amb	

Load Point	Test Series A	Test Series B	Test Series C	Connection Evaluation Envelope (CEE) Axial Point F_a	Connection Evaluation Envelope (CEE) [(1)]Pressure Point p_i or p_o	Test Load Envelope (TLE) Axial Load F_a	Test Load Envelope (TLE) Pressure Load p_i or p_o	Bend	Temp	Test Level
20$_a$95	•	•		0.90/0.95 x ~~min(Fc^a,~~CEE$^a c$~~)~~	100% CEE$^a p_i$	0.95 x LP 20$_a$95 CEE$^a F_a$	0.95 x LP 20$_a$95 CEE$^a p_i$	Yes	Amb	
21$_a$95	•	•		~~min(Fca,~~CEE$^a c$~~)~~	0	0.90 x LP 21$_a$95 CEE$^a F_a$	0		Amb	
22$_a$95	•			(~~1~~2) 0.90/A x ~~min(Fc^a,~~CEE$^a c$~~)~~	100% CEE$^a p_o$	(~~1~~2) A x LP 22$_a$95 CEE$^a F_a$	(~~1~~2) A x LP 22$_a$95 CEE$^a p_o$		Amb	
23$_a$95	•			(~~1~~2) 0.50/A x ~~min(Fc^a,~~CEE$^a c$~~)~~	100% CEE$^a p_o$	(~~1~~2) A x LP 23$_a$95 CEE$^a F_a$	(~~1~~2) A x LP 23$_a$95 CEE$^a p_o$		Amb	
24$_a$95	•			0	100% CEE$^a p_o$	0	(~~1~~2) A x LP 24$_a$95 CEE$^a p_o$		Amb	95%
25$_a$95	•			(~~1~~2) 0.33/A x ~~min(Ft^a,~~CEE$^a t$~~)~~	100% CEE$^a p_o$	(~~1~~2) A x LP 25$_a$95 CEE$^a F_a$	(~~1~~2) A x LP 25$_a$95 CEE$^a p_o$		Amb	
26$_a$95	•			(~~1~~2) 0.67/A x ~~min(Ft^a,~~CEE$^a t$~~)~~	100% CEE$^a p_o$	(~~1~~2) A x LP 26$_a$95 CEE$^a F_a$	(~~1~~2) A x LP 26$_a$95 CEE$^a p_o$		Amb	
27$_a$95	•			(~~1~~2) 0.90/A x ~~min(Ft^a,~~CEE$^a t$~~)~~	100% CEE$^a p_o$	(~~1~~2) A x LP 27$_a$95 CEE$^a F_a$	(~~1~~2) A x LP 27$_a$95 CEE$^a p_o$		Amb	
10$_a$90	•	•		~~min(Ft^a,~~CEE$^a t$~~)~~	0	0.90 x LP 10$_a$90 CEE$^a F_a$	0		Amb	
11$_a$90		•				0.90 x LP 13$_a$90 CEE$^a F_a$	0.25 x 0.90 x LP 13$_a$90 CEE$^a p_i$		Amb	
12$_a$90	•	•				0.90 x LP 13$_a$90 CEE$^a F_a$	0.50 x 0.90 x LP 13$_a$90 CEE$^a p_i$		Amb	
13$_a$90	•	•		0.90/0.90 x ~~min(Ft^a,~~CEE$^a t$~~)~~	100% CEE$^a p_i$	0.90 x LP 13$_a$90 CEE$^a F_a$	0.90 x LP 13$_a$90 CEE$^a p_i$	Yes	Amb	
14$_a$90	•	•	•	0.80/0.90 x ~~min(Ft^a,~~CEE$^a t$~~)~~	100% CEE$^a p_i$	0.90 x LP 14$_a$90 CEE$^a F_a$	0.90 x LP 14$_a$90 CEE$^a p_i$	Yes	Amb	
15$_a$90	•	•		F_{CEPL}	100% CEE$^a p_i$	~~F_{CEPL}~~0.90 x LP 15$_a$90 CEE$^a F_a$	0.90 x LP 15$_a$90 CEE$^a p_i$		Amb	
16$_a$90	•	•		0	100% CEE$^a p_i$	0	0.90 x LP 16$_a$90 CEE$^a p_i$	Yes	Amb	90%
17$_a$90	•	•		0.25/0.90 x ~~min(Fc^a,~~CEE$^a c$~~)~~	100% CEE$^a p_i$	0.90 x LP 17$_a$90 CEE$^a F_a$	0.90 x LP 17$_a$90 CEE$^a p_i$	Yes	Amb	
18$_a$90	•	•		0.50/0.90 x ~~min(Fc^a,~~CEE$^a c$~~)~~	100% CEE$^a p_i$	0.90 x LP 18$_a$90 CEE$^a F_a$	0.90 x LP 18$_a$90 CEE$^a p_i$	Yes	Amb	
19$_a$90	•	•		0.75/0.90 x ~~min(Fc^a,~~CEE$^a c$~~)~~	100% CEE$^a p_i$	0.90 x LP 19$_a$90 CEE$^a F_a$	0.90 x LP 19a90 CEE$^a p_i$	Yes	Amb	
20$_a$90	•	•		0.90/0.90 x ~~min(Fc^a,~~CEE$^a c$~~)~~	100% CEE$^a p_i$	0.90 x LP 20$_a$90 CEE$^a F_a$	0.90 x LP 20$_a$90 CEE$^a p_i$	Yes	Amb	
21$_a$90	•	•		~~min(Fc^a,~~CEE$^a c$~~)~~	0	0.90 x LP 21$_a$90 CEE$^a F_a$	0		Amb	
22$_a$90	•			(~~2~~3) 0.90/B x ~~min(Fc^a,~~CEE$^a c$~~)~~	100% CEE$^a p_o$	(~~2~~3) B x LP 22$_a$90 CEE$^a F_a$	(~~2~~3) B x LP 22$_a$90 CEE$^a p_o$		Amb	

Load Point	Test Series A	Test Series B	Test Series C	Connection Evaluation Envelope (CEE) Axial Point F_a	Connection Evaluation Envelope (CEE) [(1)]Pressure Point p_i or p_o	Test Load Envelope (TLE) Axial Load F_a	Test Load Envelope (TLE) Pressure Load p_i or p_o	Bend	Temp	Test Level
23$_a$90	•			(~~2~~3) 0.50/B x ~~min(Fc^a,~~CEE$^a c$~~)~~	100% CEE$^a p_o$	(~~2~~3) B x LP 23$_a$90 CEE$^a F_a$	(~~2~~3) B x LP 23$_a$90 CEE$^a p_o$		Amb	
24$_a$90	•			0	100% CEE$^a p_o$	0	(~~2~~3) B x LP 24$_a$90 CEE$^a p_o$		Amb	
25$_a$90	•			(~~2~~3) 0.33/B x ~~min(Ft^a,~~CEE$^a t$~~)~~	100% CEE$^a p_o$	(~~2~~3) B x LP 25$_a$90 CEE$^a F_a$	(~~2~~3) B x LP 25$_a$90 CEE$^a p_o$		Amb	
26$_a$90	•			(~~2~~3) 0.67/B x ~~min(Ft^a,~~CEE$^a t$~~)~~	100% CEE$^a p_o$	(~~2~~3) B x LP 26$_a$90 CEE$^a F_a$	(~~2~~3) B x LP 26$_a$90 CEE$^a p_o$		Amb	
27$_a$90	•			(~~2~~3) 0.90/B x ~~min(Ft^a,~~CEE$^a t$~~)~~	100% CEE$^a p_o$	(~~2~~3) B x LP 27$_a$90 CEE$^a F_a$	(~~2~~3) B x LP 27$_a$90 CEE$^a p_o$		Amb	
28$_a$90			•			LP 14$_a$90 TLE$^a F_a$ - LP 14$_a$90 F_{CEPL}	0		Amb	
29$_a$90			•			LP 28$_a$90 TLE$^a F_a$ + F_{CEPL}	0.20 x LP 14$_a$90 TLE$^a p_i$		Amb	
30$_a$90			•			0.05 x LP 28$_a$90 TLE$^a F_a$ + F_{CEPL}	~~(3)~~ LP 14$_a$90 TLE$^a p_i$		Amb	
31$_a$90			•			0.05 x LP 28$_a$90 TLE$^a F_a$ + F_{CEPL}	0.20 x LP 14$_a$90 TLE$^a p_i$		Amb	
13$_{Cycle}$	•					LP 13$_e$90 TLE$^e F_a$ +(K$_{150°}$ – K$_{temp}$)/(1 – K$_{temp}$) x (LP 13$_a$90 TLE$^a F_a$ – LP 13$_e$90 TLE$^e F_a$)	LP 13$_e$90 TLE^e p_i +(K$_{150°}$ – K$_{temp}$)/(1 – K$_{temp}$) x (LP 13$_e$90 TLE$^e p_i$)		150°F (65°C)	90%
10$_e$	•	•		~~min(Ft^e,~~CEE$^e t$~~)~~	0	0.90 x LP 10$_e$90 CEE$^e F_a$	0		Elev	
11$_e$		•				0.90 x LP 13$_e$90 CEE$^e F_a$	0.25 x 0.90 x LP 13$_e$90 CEE$^e p_i$		Elev	
12$_e$	•	•				0.90 x LP 13$_e$90 CEE$^e F_a$	0.50 x 0.90 x LP 13$_e$90 CEE$^e p_i$		Elev	
13$_e$	•	•		0.90/0.90 x ~~min(Ft^e,~~CEE$^e t$~~)~~	100% CEE$^e p_i$	0.90 x LP 13$_e$90 CEE$^e F_a$	0.90 x LP 13$_e$90 CEE$^e p_i$	Yes	Elev	
14$_e$	•	•	•	0.80/0.90 x ~~min(Ft^e,~~CEE$^e t$~~)~~	100% CEE$^e p_i$	0.90 x LP 14$_e$90 CEE$^e F_a$	0.90 x LP 14$_e$90 CEE$^e p_i$	Yes	Elev	
15$_e$	•	•		F_{CEPL}	100% CEE$^e p_i$	~~F_{CEPL}~~0.90 x LP 15$_e$90 CEE$^e F_a$	0.90 x LP 15$_e$90 CEE$^e p_i$		Elev	
16$_e$	•	•		0	100% CEE$^e p_i$	0	0.90 x LP 16$_e$90 CEE$^e p_i$	Yes	Elev	
17$_e$	•	•		0.25/0.90 x ~~min(Fc^e,~~CEE$^e c$~~)~~	100% CEE$^e p_i$	0.90 x LP 17$_e$90 CEE$^e F_a$	0.90 x LP 17$_e$90 CEE$^e p_i$	Yes	Elev	
18$_e$	•	•		0.50/0.90 x min(Fc^e,CEE$^e c$~~)~~	100% CEE$^e p_i$	0.90 x LP 18$_e$90 CEE$^e F_a$	0.90 x LP 18$_e$90 CEE$^e p_i$	Yes	Elev	

Load Point	Test Series			Connection Evaluation Envelope (CEE)		Test Load Envelope (TLE)		Bend	Temp	Test Level
	A	B	C	Axial Point F_a	(1)Pressure Point p_i or p_o	Axial Load F_a	Pressure Load p_i or p_o			
19$_e$	•	•		0.75/0.90 x ~~min(Fc^e,~~CEE$^e c$~~)~~	100% CEE$^e p_i$	0.90 x LP 19$_e$90 CEE$^e F_a$	0.90 x LP 19$_e$90 CEE$^e p_i$	Yes	Elev	
20$_e$	•	•		0.90/0.90 x ~~min(Fc^e,~~CEE$^e c$~~)~~	100% CEE$^e p_i$	0.90 x LP 20$_e$90 CEE$^e F_a$	0.90 x LP 20$_e$90 CEE$^e p_i$	Yes	Elev	
21$_e$	•	•		~~min(Fc^e,~~CEE$^e c$~~)~~	0	0.90 x LP 21$_e$90 CEE$^e F_a$	0		Elev	
22$_e$	•			(~~2~~4) 0.90/B x ~~min(Fc^e,~~CEE$^e c$~~)~~	100% CEE$^e p_o$	(~~2~~4) B x LP 22$_e$90 CEE$^e F_a$	(~~2~~4) B x LP 22$_e$90 CEE$^e p_o$		Elev	
23$_e$	•			(~~2~~4) 0.50/B x ~~min(Fc^e,~~CEE$^e c$~~)~~	100% CEE$^e p_o$	(~~2~~4) B x LP 23$_e$90 CEE$^e F_a$	(~~2~~4) B x LP 23$_e$90 CEE$^e p_o$		Elev	90%
24$_e$	•			0	100% CEE$^e p_o$	0	(~~2~~4) B x LP 24$_e$90 CEE$^e p_o$		Elev	
25$_e$	•			(~~2~~4) 0.33/B x ~~min(Fc^e,~~CEE$^e t$~~)~~	100% CEE$^e p_o$	(~~2~~4) B x LP 25$_e$90 CEE$^e F_a$	(~~2~~4) B x LP 25$_e$90 CEE$^e p_o$		Elev	
26$_e$	•			(~~2~~4) 0.67/B x ~~min(Fc^e,~~CEE$^e t$~~)~~	100% CEE$^e p_o$	(~~2~~4) B x LP 26$_e$90 CEE$^e F_a$	(~~2~~4) B x LP 26$_e$90 CEE$^e p_o$		Elev	
27$_e$	•			(~~2~~4) 0.90/B x ~~min(Fc^e,~~CEE$^e t$~~)~~	100% CEE$^e p_o$	(~~2~~4) B x LP 27$_e$90 CEE$^e F_a$	(~~2~~4) B x LP 27$_e$90 CEE$^e p_o$		Elev	

NOTE 1 The CEE pressure load is dependent on the applied axial load and individually calculated for each load point except for F_{CEPL} which is dependent on the applied internal pressure.

NOTE~~1~~2 If the external pressure for the CEE^a is determined by the actual API collapse envelope or the external pressure portion of the actual VME envelope, A = 95%. If the external pressure for the CEE^a is determined by the nominal API collapse envelope or the proprietary high collapse envelope, A = 100 % (no scaling).

NOTE 3 If the external pressure for the CEE^a is determined by the actual API collapse envelope at ambient or the external pressure portion of the actual VME envelope at ambient, B = 90%. If the external pressure for the CEE^a is determined by the nominal API collapse envelope or the proprietary high collapse envelope, B = 100 % (no scaling).

NOTE ~~2~~4 If the external pressure for the CEE^e is determined by the actual API collapse envelope at elevated or the external pressure portion of the actual VME envelope at elevated, B = 90 %. If the external pressure for the CEE^e is determined by the nominal API collapse envelope or the proprietary high collapse envelope, B = 100 % (no scaling).