Bradenhead Pressure Management

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Background:

The Railroad Commission of Texas (RRC) currently ensures compliance with Statewide Rule 17 (SWR 17) in various ways. SWR 17 requires the reporting and management of bradenhead pressure. The management of bradenhead (or annular) pressure can vary from District to District to allow flexibility due to the unique geological conditions which affect wells across the state. The guidelines herein are intended as compliance strategies for operators in dealing with the RRC district offices and achieving compliance with SWR 17. In response to recent inquiries by operators seeking guidance, the RRC has prepared the attached procedure as a process for maintaining compliance with SWR 17.

The purpose of diagnosis of pressure on the bradenhead is to assess whether or not a loss of casing integrity has occurred. To do this, operators may determine the source of the pressure and whether gas, oil, or geothermal resources are in communication outside the production casing string. This diagnosis can be made in one of several ways, as noted later in the document.

Statewide Rule 17:

(a) All wells shall be equipped with a Bradenhead. Whenever pressure develops between any two strings of casing, the district office shall be notified immediately. No cement may be pumped between any two strings or pipe at the top of the hole, except after permission has been granted by the District Office.

(b) Any well showing pressure on the Bradenhead, or leaking gas, oil or geothermal resource between the surface and the production or oil string shall be tested in the following manner. The well shall be killed and pump pressure applied through the tubing head. Should the pressure gauge on the Bradenhead reflect the applied pressure, the casing shall be condemned and a new production or oil string shall be run and cemented. This method shall be used when the origin of the pressure cannot be determined otherwise.

Bradenhead Pressure:

Bradenhead pressure is pressure between casing strings of a well. In particular, the primary concern is the existence of pressure in the annular space between the surface casing string and the intermediate or production casing string. The casing strings are designed and constructed to contain fluids under pressure while protecting water resources that have been penetrated by the wellbore. Pressure exists between two strings of casing at all points because of differences in the densities of the fluids and subsurface pressures encountered in various strata with increasing depth.

Since wellbores are essentially pressure vessels and are designed to contain a certain amount of pressure, the existence of pressure at the surface between casing strings presents a problem only in situations where that pressure exceeds the current ability of the wellbore to contain it, or where the pressure indicates a downhole communication issue that must be addressed. As such, the RRC's rules properly seek to maintain that ability to monitor downhole conditions for the entire life of the well. In many cases a non-zero annular pressure exists and represents no issue with regard to well construction, mechanical integrity, or pressure containment. Bradenhead pressure management is designed to take the appropriate steps to maintain safe conditions and protect fresh water resources.at all times during the useful life of a well.

Wellbore Construction:

Pursuant to Statewide Rule 13 (SWR 13) wellbores are constructed to securely anchor the casings in the hole, to protect all usable quality water zones from contamination and prevent vertical migration of fluids from potentially productive intervals. The method of construction is to protect usable quality water strata with steel surface casing and cement. SWR 13 includes requirements to cement casing strings to a point at least 600 feet above the casing shoe and above any productive horizons. Usable quality water is protected when wells are constructed in accordance with this rule.

Process Overview:

Wells with bradenhead pressure must be immediately reported to the RRC pursuant to SWR 17 Operators should determine if the pressure indicates the presence of a loss of mechanical integrity or results in a pressure containment issue which must be addressed. This is done in consultation with the RRC. The procedure for initial reporting and operator actions is included in **Appendix A.**

After the initial reporting of bradenhead pressure, operators may choose to either:

1.) Continue to monitor and report again if annular pressure increases:

Or,

2.) Calculate the Annular Pressure Threshold for Surface Casing (APT-sc) and/or Annular Pressure Threshold for Intermediate Casing (APT-ic) and submit to the appropriate RRC District Office for use as trigger points above which subsequent reporting of pressures is required.

If the second option is used, and the annular pressure exceeds the calculated threshold, the operator is required to provide justification for a higher pressure threshold based on the specific well situation, mitigate the pressure, or remediate as appropriate. If an operator does not choose the second option above, a pressure greater than the initial or last reported pressure may be reportable under RRC SWR 17.

Process Methodology:

Calculation of Bradenhead Pressure Threshold:

For the purpose of this document the Annular Pressure Threshold (APT) is the pressure above which reporting and management activities will be triggered, if the operator chooses to use this option. The actual amount of pressure that can be safely contained within an annulus varies based upon the construction of the specific wellbore. However, this threshold will provide a very conservative level above which reporting and management activities are appropriate. The calculation and use of this pressure threshold will provide the operator and the RRC a tool to screen pressures. The determination of this threshold is based upon the surface casing pressure calculations for the Maximum Allowable Wellhead Operating Pressure (MAWOP), as used in American Petroleum Institute (API) Recommended Practice (RP) 90, for offshore operations **(see illustration in Appendix B and B1),** but has been adapted to reflect formation integrity of the strata at the base of the surface casing.

The APT-sc is calculated as the lesser of:

- 30% of the MIYP (minimum internal yield pressure) of the pipe body for the surface casing string; or
- 0.5 psi/ft x the surface casing setting depth.

The APT-ic is calculated as the lesser of:

- 50% of the MIYP of the pipe body for the intermediate string being evaluated; or
- 80% of the MIYP of the pipe body of the next outer casing string; or
- 75% of the MCP (minimum collapse pressure) of the inner casing, or production string.

Note: For the above calculations, for strings composed of different grades of pipe, use the specifications for the lowest weight and grade pipe. If the casing weight is not known, assume the lowest weight and grade for that casing size.

Diagnostics:

There are various potential causes of casing annulus pressure. Determining the likely source and extent of the annulus pressure requires diagnostic testing.

The following diagnostic tests should be considered when evaluating casing annulus pressure integrity:

- Initial bleed-down diagnostics to determine whether the pressure is sustained or un-sustained.
- Repeated bleed-down tests if pressure is suspected to be thermally-related.

Initial Bleed-down Diagnostics Test:

A diagnostic test that includes pressure bleed-down and subsequent monitoring of pressure buildup, or a similar diagnostic test, is recommended for each annulus as follows:

- Casing annulus pressure should be bled down through a double valve arrangement, with the inside valve being fully open.
- Bleed-downs should be performed through an appropriately-sized valve.
- Liquids released should be contained.
- Samples should be captured for comparative liquid and/or gas analysis.
- Other annuli should be monitored for pressure during bleed-down and buildup.
- For safety and operational concerns, bleed-down operations or pressure observations that involve operation of valves should be performed by the operator's representative.

Subsequent Actions:

If a well's final build-up pressure is less than APT, and pressure readings indicate no communication between strings, no additional diagnostics are required. The well should be monitored on an appropriate risk-based frequency or annually with district office approval.

If annulus pressure is above APT, further evaluation is indicated. This should be coordinated with the appropriate RRC district office and may include further diagnostics, remedial work, increased monitoring, or other, more field specific methods to assess the status of the situation.

Initial Notification:

- RRC must be notified immediately (upon pressure verification), via e-mail, letter, or phone call to the appropriate district office. Example notification is shown in **Appendix C**.
- Include the following data:
  - Observed pressure value(s) (psig).
  - Well name, number, and RRC/Lease/Well ID number and API No.
  - Identify annulus with pressure.

Optional Subsequent Notification:

- The subsequent notification can be given via email, letter, or phone message to the appropriate District Office.
- Include the following data:
  - Observed pressure value(s) (psig).
  - Well name, number, and RRC Lease/Well ID number and API No.
  - Identify annulus with pressure.
  - Statement of casing integrity and optional APT.
- Including the APT calculation enables the operator to establish a trigger point for subsequent reporting if the annular pressure exceeds APT. Example subsequent notification is included in **Appendix C**.

Upon request, operator should provide a wellbore sketch.

Potential Mitigation Techniques:

The following are some potential mitigation techniques that are applicable to certain situations after consultation with the appropriate RRC district office:

Surface Options

1. Relieve annular pressure by connecting to a gathering, VRU, combustor, flare, vent, or fuel system.

   Criteria:

   - Uniform mineral interest.
   - Low flow rate (<15 mcfd after 90 days).
   - Availability of acceptable relief system.
   - Low potential to exacerbate flow.

2. Lubricate and bleed kill-weight fluid or other shut-off materials down annulus.

3. Repeated bleed-down as a sole method of evaluation and compliance will not be allowed.

4. Other Options.

5. The District Director or its delegate may allow for exceptions to the above based on a well- by-well or on a field-wide basis.

Downhole Options

1. Perforate and squeeze.

2. Cement liner in place.

3. Replace production casing.

4. Plug and Abandon.

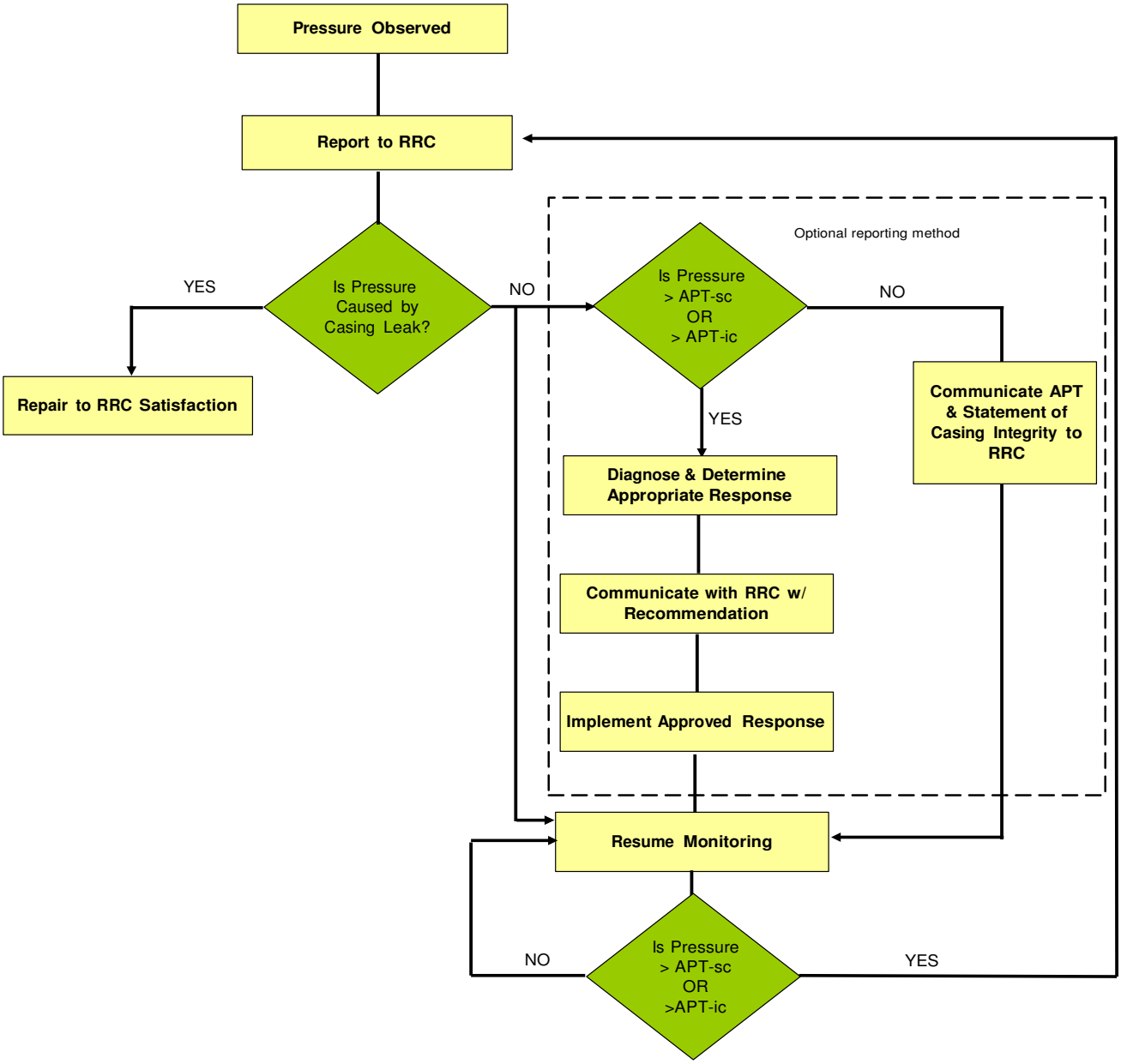
   Criteria:

   - No future utility.
   - Loss of mechanical integrity.
   - Depletion of reserves.

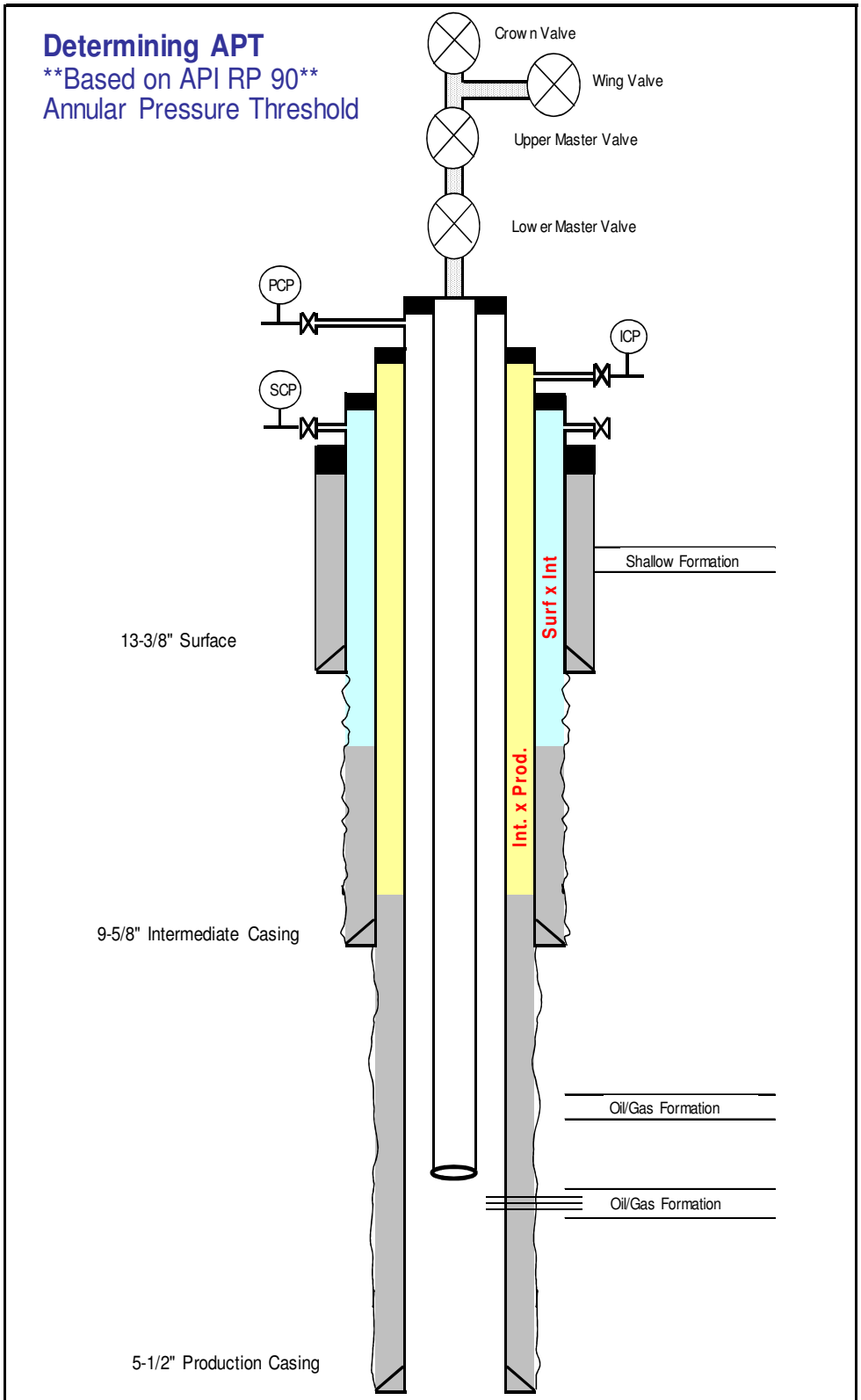
5. Offset Injection causing pressure.
    - Possible modification of injection permit interval or injection rate.
    - Remedial action on offset injection well.
    - Remedial action in subject well
6. Other Options
7. The District Director or its delegate may allow for exceptions to the above based on a well-by-well or on a field wide basis.

Appendix A:

Annular Pressure Observation / Response Flowchart



Appendix B:



		MIYP	Collapse	50% MIYP	30% MIYP	75% Collapse	80% MIYP	APT-IC	APT-SC
		psi	psi	psi	psi	psi	psi	psi	psi
Prod Tubing	2-3/8" 4.7# L-80	11200	11780	N/A	N/A	N/A	N/A	N/A	N/A
Prod Casing	5-1/2" 20# P-110	12640	11080	6320	3792	8310	10112	N/A	N/A
Int. Casing	9-5/8" 40# J-55	3950	2570	1975	1185	1927.5	3160	1384	N/A
Surface Casing	13-3/8" 48# H-40	1730	770	865	519	577.5	1384	N/A	App B-1

Appendix B1:

	APTsc, psi*	
Shoe Depth Footage	**0.5 psi/ft Gradient**	**30% MIYP****
100	50	519
200	100	519
300	150	519
400	200	519
500	250	519
600	300	519
700	350	519
800	400	519
900	450	519
1000	500	519
1100	550	519
1200	600	519
1300	650	519
1400	700	519
1500	750	519
1600	800	519
1700	850	519
1800	900	519
1900	950	519
2000	1000	519

* Note: The APT-sc is calculated as the lesser of:

- 30% of the MIYP (minimum internal yield pressure) of the pipe body for the *surface casing string: or*
- 0.5 psi/ft x the surface casing setting depth.

** Note: This example utilizes 13 3/8", 48#, H-40 casing. This will vary by well.

Appendix C:

Example Initial Notification for 3 Wells:

Operator: A. Smith Operating Company

Well Name	Well No.	RRCID / Lse No.	Annulus	Psig
Slaughter Gas Unit "B"	1	075903	Surf x prod	275
Brewster, J.T.	3	05953	Surf x prod	136
Woods, Milton (Deep) Gas Unit	5	145568	Surf x int	650
Woods, Milton (Deep) Gas Unit	5	145568	Int x prod	210

Example Subsequent Notification for 4 Wells:

Operator: A. Smith Operating Company

Well Name	Well No.	RRCID /Lse No.	Annulus	Psig	APT-ic	APT-sc
Slaughter Gas Unit "B"	1	075903	Surf x prod	275	1385	519
Brewster, J.T.	3	05953	Surf x prod	136	1385	519
Woods, Milton (Deep) Gas Unit	5	145568	Surf x int	650	1385	519
Woods, Milton (Deep) Gas Unit	5	145568	Int x prod	150	1385	519

Note: Casing annulus pressures will continue to be monitored and be reported when the pressure exceeds APT