Preventing Surface Casing Overloads

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ABSTRACT

It is the purpose of this paper to point out one of the most important factors to be considered in the proper design and correlation between the tubular material and the wellhead assembly as related to the compressive overload of the surface casing.

DISCUSSION

Before most wells are drilled today the operator has various sources of advance information that enables him to select the proper pipe and wellhead program. In other words, the operator knows his approximate total depth, estimated pressures, and depth to which it will most likely be necessary to set any intermediate casing strings that might be required. To help the operator select the required size, weight, and grade of pipe string, various formulae and/or tables are available from most oil field tubular manufacturers. For the purpose of calculations of the examples contained in this paper, data from a "Spang Engineering Data" handbook will be used.

With the casing landing method usually being determined in advance, the operator will know the estimated loads, in lb, that he will set on the casing and tubing hangers: the combination of all weight set on these casing and tubing hangers are a direct load that is transferred through the wellhead bodies to the surface casing at the point of attachment to the casing head. For this reason, a review of the surface casing weight, grade and joint strength should be made independently of the design necessary to conform to well conditions and running and landing practices.

In view of our present API standards, which establish the minimum joint strength value, but which are not specific for the modus operandi for which the joint strength values apply, and in view of the absence of contradictory published data, it is generally accepted that the API minimum tensile strength values should not be exceeded in compressively loaded joints.

CALCULATIONS OF A HYPOTHETICAL WELL

Procedure

To better explain the procedure necessary to select the proper surface casing string insure against failures because of compressive overload, one should consider a well that would have depths and a casing program as follows (Fig. 1):

Surface casing string . . . . 1,300 ft of 13 3/8 in.
Intermediate casing string . . . . 5,000 ft of 9 5/8 in.
Production casing string . . . . . 13,000 ft of 7 5/8 in.
Tubing String . . . . 12,500 ft of 2 7/8 in.

It is assumed that one will not slack off or pull any additional weight on any of the pipe string, but will hang the pipe within the wellhead bodies as it is at the time of cementing.

With the pipe strings designed for proper burst, tension and collapse, the calculated estimated casing and tubing hanger loads will be:

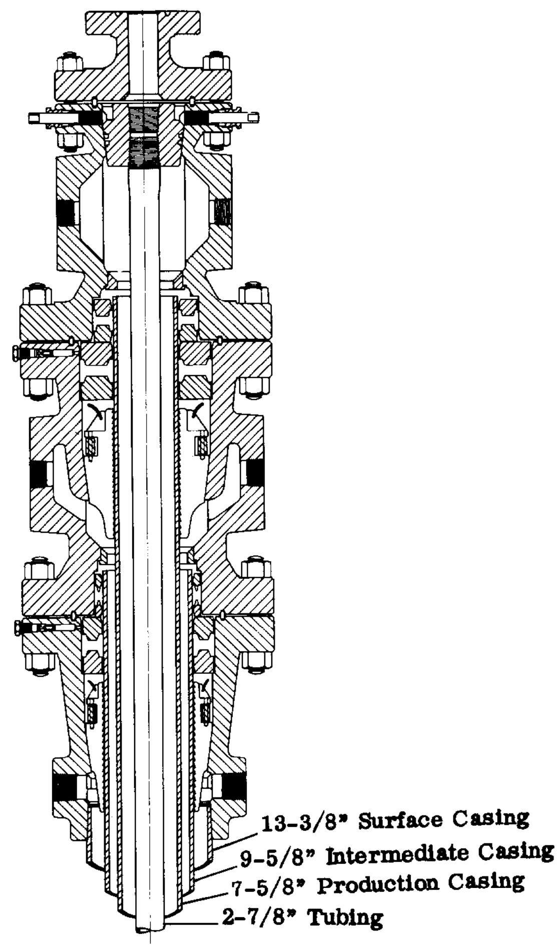
9 5/8 in. Intermediate casing string wgt . . 184,800 lb
7 5/8 in. Production casing string wgt . . . 428,130 lb
2 7/8 in. Tubing string wgt . . . . 74,750 lb
Total wgt effect on surface connection . . . 687,680 lb

This combined weight does not consider effect of bouyancy, for it usually is felt that it is better to add whatever weight loss is gained in this manner to the safety factor for unforseen circumstances. These weights are not considered excessive for a well of this nature – particularly in view of the general trend toward setting casing "as cemented".[1]

Referring to a tubular data handbook, one finds that the joint strengths of 13 3/8 in. casing are as follows:

Wgt per ft	Grade	Parting Load Reg Thd Jt (Joint Strength)
48.00 lb	F-25	260,000 lb
54.50 lb	J-55	545,000 lb
61.00 lb	J-55	613,000 lb
68.00 lb	J-55	695,000 lb
72.00 lb	N-80	868,000 lb

SKETCH NO. 1



Solution

A check of the above table shows that 13 3/8 in. OD, J-55, 68 lb, RT&C casing has a joint strength the same as that of the previously estimated total load effect. Since there would be no appreciable safety factor except bouyancy, one would most likely choose 13 3/8 in. OD 8RD, N-80, 72 lb. RT&C as his casing string.

Disadvantages

The use of the 72 lb N-80 surface casing may well exceed the operator's normal requirements as related to weight and grade necessary for well conditions and running and landing practices of the surface string itself. However, this choice would lead to an increased completion cost as well as, in some cases, difficulty in securing on short notice a particular size, weight and grade of pipe.

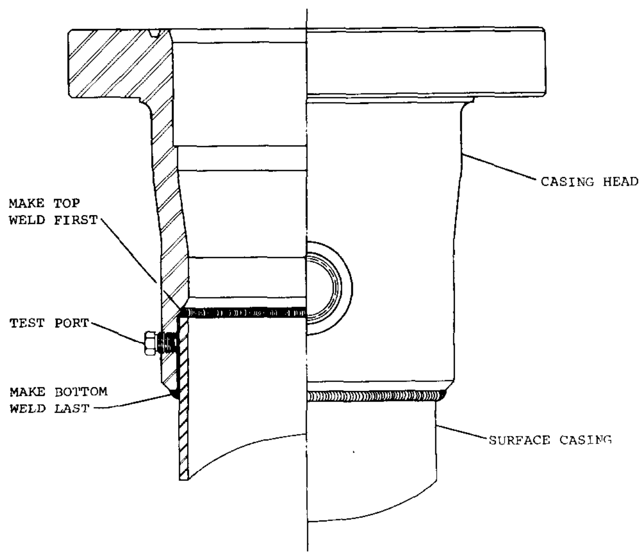
Alternatives

In order to allow the operator to lessen the weight and grade requirements of the surface pipe and at the same time to insure against a failure of the surface pipe at either the wellhead body connection or in the surface string itself, a number of different methods have been employed. The most commonly used are:

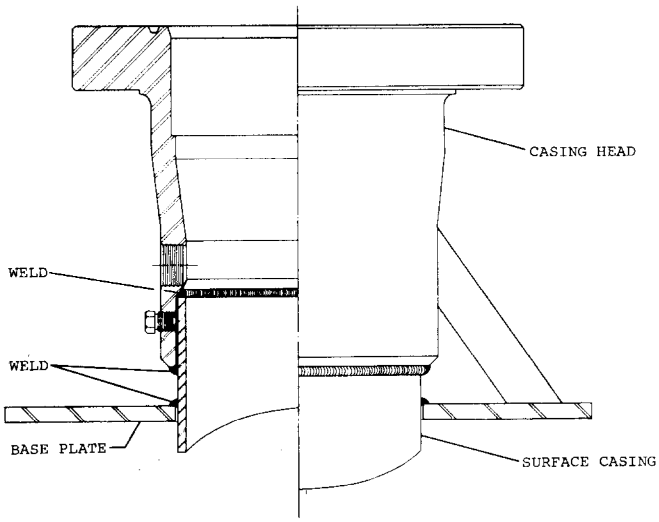
1. Reduction of Casing Hanger Weight
   One slacks off part of the casing weight on the intermediate and/or production casing string prior to final casing hanger setting. This method is the least favored by leading authorities for additional slack-off increases the buckling tendency of the pipe string and causes a possible restriction of tool passage, as well as encourages thread failures.[2]
2. Counterbore for Weld Casing Head
   The use of a counterbore for weld connection between the surface casing and wellhead (Fig. 2) permits a higher strength value at this point than that of the API minimum joint strength in the threaded connection. In this case the total load effect in pounds per sq in. would be carried by the cross sectional or wall area of the surface joint. This capacity is calculated by multiplying the wall area by the minimum yield per sq. in. of the top joint of the top joint of the surface string. A check of a tubular data binder shows that 13 3/8 in. OD J-55, 54.50 lb, RT&C casing has a wall area of 15.514 sq in. It is further noted that J-55 casing has a minimum yield of 55,000 lb per sq in. One then multiplies as follows:

   15,514 sq in. (wall area 13 3/8 in. OD J-55, 54.50 lb casing)
   x55,000 psi (Min yield J-55 casing)
   853,270 lbs (Result)

   The result will be the maximum weight that can be supported by a counterbore for weld surface connection. Taking the previously outlined hypothetical case where the estimated load effect on the surface connection was 687,680 lb, one will note that the change to the welded surface connection allows the use of a much lighter and less expensive surface string, but still provides an adequate safety factor. It must be noted, however, that method 2 requires a very good top-to-bottom cementing of the surface string. This method also calls for a surface formation strong enough to help support the load effect on the top of the surface casing. Should these conditions not be present, buckling of surface pipe may occur, and also thread failures may develop at threaded and coupled connections below the surface of the ground.
3. Structural Support Attached to the Casing Head
   When this method is used, a portion of the casing and tubing hanger loads are transferred into the surface formation, either through a reinforced concrete pad or, in marshy or off-shore locations, through a large conductor casing string. The casing head of the wellhead assembly has an intergal reinforcing (usually fabricated radial gussets) landing base plate. Casing heads of this type normally have a counterbored connection rather than a threaded connection for attachment to the surface casing (Fig. 3). If a concrete pad is employed, its depth, area, and amount of reinforcing is determined by the amount of total pipe load required to suspend and the load bearing qualities of the surface formation. After the landing base plate is properly welded to the surface pipe, effective grout should be placed between the base plate and the concrete pad.[3] In marshy or offshore locations a landing base plate has also been effectively used by resting the plate on top of the conductor casing string. Then, the landing base plate is then welded to both the conductor and surface pipe string. With the proper application of the landing base, overload of the surface pipe connection is prevented, and the possibility of down hole buckling effect and subsequent failure is eliminated. However, the satisfactory use of a landing base is dependent upon having a sufficient load bearing surface formation.
4. Larger Surface Casing and/or Special High Joint Strength Thread Connection
   Where high surface connection loads are encountered on very deep wells and/or those wells whose particular conditions make it undesirable to use any of the foregoing methods, larger surface casing and/or special high joint strength thread connections may be with the following advantages:
   a. Larger casing and tubing hanger loads may be supported, allowing the operator to set longer intermediate and production pipe strings "as cemented".
   b. As all connections of the surface string would be of the same and sufficient strength, overload of weaker surface pipe connections below ground level would be eliminated.



SKETCH NO. 2



SKETCH NO. 3

c. Load bearing qualities of the surface soil conditions as applied to the landing base method are not a factor. It should be noted, however, that this method also increases the completion cost and would, therefore, be used only in special instances.

SUMMARY

Both the drilling of deeper wells and recent trends toward "full tension" casing landing practices have resulted in heavier casing and tubing strings, which has greatly increased loads exerted upon surface pipe. This result has made it necessary for the operator to design his surface pipe string on the basis of compressive loading as well as that of burst, collapse and tension that have formerly been confined to running and landing practices alone. This practice is especially true of medium-to-deep projects. With surface connection loads having been calculated in advance, the operator must then select whichever relief method best fits his conditions if an overload is present.

A combination of several of the aforementioned corrective steps may be necessary to cope with extreme or adverse conditions.

BIBLIOGRAPHY

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2. "Casing Recommendations", API Bulletin D-7, June 1955 J. W. Peret, "Comparison of Casing Landing Methods," The Petroleum Engineer, October 1953; H. G. Texter, "Casing Strain After Cementing," The Oil and Gas Journal, April 8, 1948.
3. For proper procedure for weld between casing and wellhead, cf. "API Specification for Wellhead and Drilling - Through Equipment", API Standard 6-E, March 1958.