SLIMHOLE COUPLING DERATING FACTORS – DO WE NEED THEM?

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ABSTRACT

The history and development of slim hole coupling derating factors will be presented. These date back to the 1960s when Conoco originated the first recommendations. Later these were modified to include the comparison of the strength of the couplings versus the strength of the sucker rod. Normally, while operators may not have had problems in the past with slimhole coupling failures, there is a current concern that old practices may not be the best practices for today's new producing wells that are deeper and producing higher volumes than wells in the recent past. Additionally, new derating factors are provided if non-API higher strength, special grade rods are used. Recommendations are made as to what to do with design, installation, and selection of other potential coupling grades to prevent failures from occurring.

INTRODUCTION

Slim hole (SH) coupling derating factors have been developed and are recommended to be used as an industry best practice. These have been published and presented in a number of papers and books; but, there is still some controversy about the potential need or when to use a derating factor. A reference comparison table which was developed by a downhole pump manufacturer shows the various sizes of standard downhole equipment.[1] Selecting a specific casing size, the table shows the minimum possible equipment diameters could be run in the corresponding production tubing sizes. This is the first start to consider if slim hole sucker rod couplings would be required since it points out for a given tubing size, what full sized and slim hole couplings could be run. This paper will provide a historic background on the development and use of the SH derating factors along with recommendations for consideration if special extra high strength sucker rod grades are used.

BACKGROUND

The first SH derating factors were developed by Conoco[2]. These were based on comparing the cross sectional area of full sized couplings versus the cross sectional area for the various corresponding standard rod body diameters. Then the comparison of coupling areas for full sized (FS) couplings were compared to the reduced cross sectional area for slim hole couplings. It is shown that the full sized coupling area ranges from 2.6 to 3.4 times the related rod area depending on the rod diameter. Since this area is so much greater by design than the sucker rod body, one would expect little, if any, couplings to ever fail. However, couplings and connection failures have occurred; but, these problems have been addressed elsewhere.

When a slim hole coupling is used, the cross sectional area and related load/stress carrying capability of the coupling is reduced. Gipson and Swaim considered this simple area reduction to produce the first derating factors. After making the first derating factor recommendations, feedback from the field showed there was not any 1" slim hole coupling failures. Thus, the final derating factors were normalized by dividing the cross sectional area of the 1" slim hole coupling into the ratio of the slim hole to full sized coupling area. Table III provides the final, normalized slim hole coupling derating factors that were used for many years.

In the early 1980's, Dean Hermanson considered other factors that might affect the coupling derating factors.[4] One of the considerations was the strength of the different grades of rods compared to the strength of the coupling material. While the original derating factors could be applied for the various rod diameter as long as C or K grade rods were installed. As shown in Table IV, the minimum tensile strength of these rods (90,000 psi) is less than the minimum tensile of the API T grade coupling (95,000 psi).[3] However, if any of the three API D grade rods were

used with API T grade couplings, then the coupling load/stress carrying capability is reduced since it is now not as strong as the D grade rod (115,000 psi minimum).

Multiplying the minimum requirements for the strength of the various API rod grades versus the API T class coupling and then multiplying these ratios times the area ratios resulted in the slim hole coupling derating factors shown in Table V. It should be noted that for many years there was a difference in strength requirements for C and K grade rods (90,000 KSI versus 85,000 psi). So when the higher strength T class coupling was compared, there were different derating factors developed for these grades. In the 1990s, when both C and K were required to have the same strength, 90,000 psi, then both now have the same derating factor.

In the 1970s, when special, higher strength, non-API sucker rod material were developed, another derating of the coupling should be considered. Since this grade of rod typically has a tensile strength of 140,000 to 150,000 psi (and some manufacturers have even higher strength up to 160,000 psi), if normal API full sized coupling would be used versus the special rod grades, these may need a reduction due to reduced rod area to coupling area relationship times the tensile strength relationship. The derating factor for full sized T grade coupling when installed on special high strength (HS) rods are provided in the far right column of Table VI.

If slimhole couplings are used with the special, higher strength rods, then these couplings have much lower load/stress carrying capabilities and drastic slim hole coupling derating factors as shown in Table VI should be considered.

It should be noted that for every condition, the 7/8” diameter rod versus coupling area is the lowest ratio. This always results in the highest derating factor for this sized rod.

CURRENT DESIGN CONSIDERATIONS

If the selection of rod diameter versus tubing diameter requires a slim hole coupling to be used, then the appropriate slim hole coupling derating factor for the grade of rod and the size of the coupling should be used. The oil and gas production industry have accepted the potential affect of the decreased area and strength affecting the load/stress carrying capabilities and adopted the recommendations in Table V in API RP 11BR.[5]

Some operators have suggested that the slim hole coupling derating factors should not be used since they had not experienced any failures when these have been used. However, this may be due to the manufacturer supplying the T class couplings provided them in a much higher strength (~115 to 125,000 psi) versus the minimum 95,000 psi requirement in API Spec 11B. As such, the load/stress carrying capabilities have been increased over the minimum tensile that was considered for development of the factors. While the operator may have extra coupling capabilities, unless the manufacturer guarantees the higher strength, there will always be the possibility that the lower minimum tensile will be provided, unless the purchase agreement states higher strengths are desired and the higher price for the higher strength is negotiated.

There have been some coupling manufacturers that have developed new, higher strength couplings. These may have a minimum tensile strength of 125,000 psi and would be a good match for most D grade rods, especially if the rods are manufactured with equal or lower strength. But, it should be noted that even these higher strength couplings may not have the same strength/load/stress capacity as the special high strength rods. So, a slight derating factor may be required.

One of the ways to reduce the problem of derating couplings is to assure full sized couplings are always used. But, according to Table I, larger tubing for the upper part of the production tubing string may be required to accommodate the rods, even though smaller tubing will be sufficient for the installed pump and rods on bottom of the well. This then would require a tapered tubing string.

One final consideration for equipment selection, when sucker rod couplings are spray metal coated, typically the coupling diameter is reduced 0.010 to 0.020” in order to accommodate the thickness of the spray metal coating. This additional coupling area reduction can be accommodated with full sized couplings but, it becomes even more difficult to assure adequate load/stress capabilities if slim hole couplings are spray metal coated. It is for this reason

that it is recommended to "never" use spray metal coated, slim hole couplings unless the strengths of the rods grades and coupling grades are known and properly approved by the manufacturer and the operator.

CONCLUSIONS & RECOMMENDATIONS

1. Gipson and Swaim's mathematical comparison of areas originally resolved connections failing; but this compared nominal C grade rods versus T grade couplings.
2. Hermanson said that if D grade rods are used versus T grade couplings, then the derating factor may need to be further reduced.
3. Extending the strength comparison to special HS rods says the derating needs further reduction not only for slimhole couplings, but also for full sized couplings depending on the comparison of the rod versus coupling strength (when extra high strength rods are used).
4. Rod string designs need to consider the potential of applying the slimhole coupling derating factor or at least provide to the operator that a failure potential may exist.
5. If don't want or can't derate rod string, then operator needs to run the correct sized tubing in the length requiring slimhole couplings so full sized couplings can be run.
6. Further, the operator could consider a tapered tubing string where the tubing size and length are selected to enable full sized couplings to be run for the entire rod string
7. Or the operator could consider running special HS couplings, if available for the rod size required.
8. Many rod strings have been installed w/o excessive failures even though slimhole couplings were run.
9. Some believe there is not a need to derate; but there has been recent rash of coupling failures high in the string.
10. Operators may want to consider running a higher risk, "pilot" string with slimhole couplings without derating to see if there are operational problems/failures. Then make appropriate adjustment if failures occur.
11. The main consideration is the strength of the materials used for couplings versus the rods. While the API provides minimum strength requirements, if the actual manufacturers rods and coupling strength are known, then there also may not need to use a recommended derating factor.

REFERENCES

1. Williams, Benny; "Comparison Table for Sucker Rod Lift Equipment Sizing and Selection," Harbison-Fischer, Crowley, TX, 2005
2. Gipson, F. W. and Swaim, H. W.; *Beam Pumping Fundamentals, SWPSC, Lubbock, TX; Continental Oil Company, 1969.*
3. API Spec 11B*; Specification for Sucker Rods, Polished Rods and Liners, Couplings, Sinker Bars, Polished Rod Clamps, Stuffing Boxes, and Pumping Tees*, API, 27th edition, Nov 1, 2010, Washington, D.C.
4. Hermanson, D. F., *Sucker Rods and Couplings,* SPE Petroleum Engineering Handbook, ed. Bradley, 1987, Richardson, TX.
5. API RP 11BR; *Recommended Practice for the Care and Handling of Sucker Rods,* API, 9th edition, August 2008, Washington, D.C.

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Table I

Harbison Fischer Recommendations for Installation, Design, Selection and Fit ©

Casing Size	Tubing Size, Max	Sucker Rod Size, Max	RW Insert Pump, Max	RXB* Insert Pump, Max	RH Insert Pump, Max	TH Tubing Pump, Max	Oversize Tubing Pump, Max
2-3/8", 4.7#	1-1/4" Reg. 1.660" OD, 1.380" ID, 1.286" drift	1/2" (1" OD Cplgs)	1"	n/a	n/a	1-1/4"	1-1/2"
2-7/8", 6.5#	1-1/2" Reg. (1.900" OD, 1.610" ID, 1.516" Drift)	5/8", Slim Hole Cplgs	1-1/4"	n/a	n/a	1-1/2"`	2"
3-1/2", 7.7-10.2#	2-1/16" Integral Jnt	3/4", Slim Hole Cplgs	1-1/4"	1-1/4"	n/a	1-1/2"	2"
4", 9.5-14.0#	2-3/8"	7/8" Slim Hole Cplgs	1-1/2"	1-1/2"	1-1/4"	1-3/4"	2-1/4"
4-1/2", 9.5-12.6#	2-7/8" Spec Clear Cplg	1", Slim Hole Cplgs	2"	2"	1-3/4"	2-1/4"	2-3/4"
5", 11.5-20.3#	2-7/8"	1" Slim Hole Cplgs	2"	2"	1-3/4"	2-1/4"	2-3/4"
5-1/2", 14-20#	3-1/2" Flush Joint	1-1/8"	2-1/2"	n/a	2-1/4"	2-3/4"	3-3/4"
6-5/8", 20-28#	3-1/2"	1-1/8"	2-1/2"	n/a	2-1/4"	2-3/4"	3-3/4"
7", 17-29#	4-1/2"	1-1/8"	3-1/4"	n/a	2-3/4"	3-3/4"	4-3/4"
7-5/8" and Larger	4-1/2"	1-1/8"	3-1/4"	n/a	2-3/4"	3-3/4"	5-3/4"

* The RXB pump has a heavy wall barrel that is internally threaded the same as an RW pump. It can only be used as a bottom hold-down pump since the outside diameter of the barrel is too large to pass through a seating nipple.

Note: <u>These are maximum sizes.</u> Smaller tubing, sucker rods or pumps can be used than those shown for any particular row of maximum size choices.

Table II

Comparison of sucker rod body area to full sized coupling area (Ref.1)

Nominal Coupling Size (in)	$(OD\ area)^2$ - $ID\ area)^2$ $(in)^2$	Rod Body Area $(in)^2$	(Delta Coupling Area)/ Rod Area
5/8	1.0508	0.307	3.4228
3/4	1.1579	0.442	2.6197
7/8	1.4398	0.601	2.3957
1	2.2342	0.785	2.8461
1- 1/8	2.4694	0.994	2.4843

Table III

Normalized slimhole coupling area comparison relative to 1” slimhole coupling area and resulting derating recommendations (Ref 1)

Nominal Coupling Size (in)	Delta Coupling Area $(in)^2$	(Delta Area)/ Rod Body Area	Normalized Derating (prior column)/2.0606
½	0.3234	1.6471	0.7993
5/8	0.5109	1.6642	0.807
¾	0.8510	1.9253	0.9343
7/8	0.9337	1.5536	0.7540
1	1.6176	2.0606	1.000

Table IV

API Spec 11B mechanical property requirements for the various grades of sucker rods compared to standard class T coupling (Ref 2)

Rod Grade	Tensile Range (ksi)	Coupling Tensile (ksi)
C &K	90 to 115	95 min
All 3 D	115 to 140	(56 to 62 HRa)
Special HS	140 to 150 (155; 160)	

Table V

Modification of slimhole coupling derating factors based on material strength (Ref 3)

API Rod Size (in)	API Grade K	API Grade C	API Grade D
5/8	Na	0.97	0.77
¾	Na	Na	0.86
7/8	0.93	0.88	0.69
1	na	Na	0.89

Table VI

Modified slimhole coupling derating factors if high strength rods or high strength couplings are considered

	Slim Hole Couplings				Full Size
Rod Size	K	C	D	HS	HS
3/4 “	*	*	.85	.71	.94
7/8”	.93	.88	.69	.57	.85
1”	*	*	.89	.74	*