Deep-Well Drill Pipe Grade Selection and Upper-String Load Review

Data-centered review for determining whether X95, G105 or S135 provides adequate upper-string tensile margin after buoyancy, overpull, dynamic allowance, wall loss and assembly limits are included.

Main question	Grades covered	Review sequence
How does calculated upper-string load compare with the remaining pipe-body section and grade strength?	X95, G105 and S135	Load build-up -> remaining section -> pipe-body capacity -> assembly limit -> grade decision

1. API 5DP Strength Baseline

Grade	Minimum Yield Strength	Maximum Yield Strength	Minimum Tensile Strength	Deep-Well Review Position
X95	95 ksi / 655 MPa	125 ksi / 862 MPa	105 ksi / 724 MPa	Intermediate grade where calculated upper-string load and overpull remain inside the X95 margin.
G105	105 ksi / 724 MPa	135 ksi / 931 MPa	115 ksi / 793 MPa	Common higher-strength review grade for deeper wells and heavier strings.
S135	135 ksi / 931 MPa	165 ksi / 1,138 MPa	145 ksi / 1,000 MPa	Reviewed where hook load, overpull or wall loss reduces the available G105 margin.

Screening rule: grade strength must be applied to the remaining pipe-body cross-sectional area. A higher grade does not by itself establish usable tensile capacity.

2. Upper-String Load Inputs and Screening Equations

Load Input	Engineering Meaning	Effect on Grade Selection
Air weight of drill string	Total string weight before buoyancy correction.	Starting point for deep-well axial load.
Mud density	Controls buoyancy reduction of the submerged string.	Higher mud density reduces effective string weight.
Maximum expected hook load	Maximum measured or modeled load at surface.	Should be reconciled with the calculated load build-up.
Planned overpull	Additional tension reserved for stuck-pipe recovery.	Directly reduces remaining tensile margin.
Dynamic load allowance	Allowance for transient movement, acceleration and operating variation.	Added before comparing with usable tensile capacity.
BHA weight	Weight contribution below the drill pipe section.	Included in the accumulated upper-string load.
Remaining wall / wear allowance	Actual metal section after wall loss or inspection classification.	Reduces pipe-body area and yield capacity.
Project design factor	Project-defined margin applied to the calculated operating load or rated capacity.	No universal value should be assumed without the design basis.

Approximate buoyancy factor

$$BF = 1 - MW / 65.5$$

Buoyed string weight

$$W_{\beta} = W_{air} \times BF$$

Design operating load

$$L_{screen} = W_{\beta} + \text{Overpull} + \text{Dynamic allowance}$$

Mud Weight	Approx. Buoyancy Factor	Buoyed Weight from 400,000 lb Air Weight
9 ppg	0.863	345,038 lb
10 ppg	0.847	338,931 lb
12 ppg	0.817	326,718 lb
14 ppg	0.786	314,504 lb

The buoyancy formula is an engineering screening approximation for steel in drilling fluid. Final load modeling should follow the project drill string model and operating program.

3. Remaining Pipe-Body Section and Grade Capacity

The pipe-body section is determined from OD and remaining wall thickness. The calculations below use a 5.000 in OD, 0.362 in nominal wall example to show how wall loss changes X95, G105 and S135 screening capacity.

Remaining wall	Remaining ID	Metal area	Screening yield load
$t_r = t_{nom} \times RBW$	$ID_r = OD - 2t_r$	$A = \pi/4 \times (OD^2 - ID_r^2)$	$P_y = A \times SMYS$

Remaining Body Wall	Remaining Wall	Metal Area	X95 Screening Yield	G105 Screening Yield	S135 Screening Yield
100%	0.362 in	5.275 in²	501,087 lb	553,833 lb	712,070 lb
95%	0.344 in	5.030 in²	477,890 lb	528,194 lb	679,107 lb
90%	0.326 in	4.784 in²	454,498 lb	502,340 lb	645,865 lb
80%	0.290 in	4.286 in²	407,127 lb	449,982 lb	578,549 lb

Interpretation: at the same OD and remaining wall, grade strength changes the theoretical pipe-body yield load. Wall loss reduces capacity across every grade, so inspection class and actual wall thickness must be fixed before X95, G105 and S135 are compared.

These values are simplified uniform-wall screening calculations. Certified performance sheets, actual dimensions, tolerances, connection limits and project safety factors govern final use.

4. Worked Upper-String Load Case

The following example shows how the load build-up is compared with the remaining-section capacity. It is an illustrative screening case, not a universal operating recommendation.

Input / Result	Value	Calculation / Meaning
Air weight	420,000 lb	Modeled drill string weight before buoyancy correction.
Mud weight	12.0 ppg	Used in the approximate buoyancy factor.
Buoyancy factor	0.817	1 - 12.0 / 65.5
Buoyed string weight	343,053 lb	420,000 x buoyancy factor
Planned overpull	60,000 lb	Additional stuck-pipe recovery load.
Dynamic allowance	20,000 lb	Illustrative transient-load allowance.
Calculated operating load	423,053 lb	Buoyed weight + overpull + dynamic allowance
Illustrative required capacity at 1.15 factor	486,511 lb	Project factor shown only to demonstrate margin sensitivity.

Grade	80% RBW Screening Capacity	Margin vs 423,053 lb Load	Result at Illustrative 1.15 Requirement
X95	407,127 lb	-15,927 lb	Below requirement
G105	449,982 lb	+26,929 lb	Below requirement
S135	578,549 lb	+155,495 lb	Above requirement

Screening outcome: X95 falls below the calculated operating load. G105 retains only a small raw margin and falls below the illustrative 1.15 requirement. S135 retains the largest margin in this example. Final selection still requires the certified pipe-body, connection and elevator capacities.

5. Published Same-Geometry Performance Reference

A public 2025 performance reference for 5.000 in x 19.50 lb/ft, 0.362 in wall, IEU, R2, NC50 drill pipe allows G105 and S135 to be compared at the same geometry and Premium Class 80% remaining body wall.

Reference Item	G105	S135	Selection Meaning
Pipe body OD / wall	5.000 in / 0.362 in	5.000 in / 0.362 in	Geometry is held constant.
Remaining body wall	0.290 in	0.290 in	Both sheets use Premium Class 80%.
Published tensile strength	436,150 lb	560,760 lb	S135 adds 124,610 lb in the published zero-torque body reference.
Published torsional strength	45,200 ft-lb	58,110 ft-lb	Pipe-body torsional capacity also rises with grade.
NC50 maximum make-up torque, 1.0 FF	30,700 ft-lb	30,700 ft-lb	The same connection does not gain a higher MUT simply because pipe-body grade increases.
Connection tension at max MUT	1,118,500 lb	1,118,500 lb	In pure tension, pipe body controls before this published connection value in both examples.

Key point: the same connection can remain unchanged while the pipe-body tensile capacity changes materially. Deep-well selection should therefore compare the required load with both the pipe-body rating and the assembly limits.

Published values are reference data and state that no safety factor is applied. Final use requires the applicable performance sheet, current inspection data and project design margin.

6. Torque-Tension Interaction and the Governing Limit

Deep wells are often screened first by axial tension, but operating torque can reduce the allowable combined-load envelope. The governing capacity is the lowest verified limit in the complete assembly.

Assembly Limit	What to Verify	Why It Can Govern
Pipe-body tensile capacity	Grade, OD, actual wall and inspection class.	Controls when the remaining body section reaches yield first.
Tool joint tensile capacity	Tool joint OD / ID, material and wear.	Can control when tool joint section or wear reduces capacity.
Connection combined-load envelope	Operational torque, make-up torque, shoulder contact and thread condition.	Available tension decreases as operational torque increases.
Elevator shoulder capacity	Elevator bore, tool joint OD and shoulder wear.	Hoisting equipment contact can become the upper-string limit.
Project design margin	Required design factor and transient operating allowance.	Converts reference capacity into an approved operating limit.

Operational Torque	Published G105 Assembly Max Tension	Reduction from Zero-Torque Value
0 ft-lb	436,100 lb	0 lb
18,400 ft-lb	398,400 lb	37,700 lb
27,600 ft-lb	345,400 lb	90,700 lb
35,000 ft-lb	276,000 lb	160,100 lb

Engineering reading: a zero-torque tensile figure should not be used as the final operating limit when the upper string also transmits substantial torque. The applicable torque-tension envelope and connection make-up condition must be checked.

Published combined-load example: 5.000 in x 0.362 in G105, NC50, Premium Class 80%, friction factor 1.0. The source states a safety factor of 1.0.

7. Deep-Well Grade Boundary Matrix

Review Condition	X95	G105	S135
Upper-string operating load	Within X95 remaining-section margin.	X95 margin insufficient; G105 remains adequate.	G105 margin insufficient or too small after design factor.
Planned overpull	Moderate allowance within X95 capacity.	Higher recovery allowance requires additional margin.	High overpull materially reduces G105 remaining margin.
Remaining body wall	Requires verified wall sufficient for X95 load.	Wall loss can erase the benefit over X95.	Higher grade preserves more load capacity at the same remaining section.
Tool joint / connection	Must exceed the X95 pipe-body requirement.	Must support higher body load and operating torque.	Higher pipe grade has no value if the same connection becomes the limit.
Typical decision	Controlled medium-depth or lower-load deep-well case.	Common deep-well review grade.	Higher hook load, reduced G105 margin or demanding recovery load.

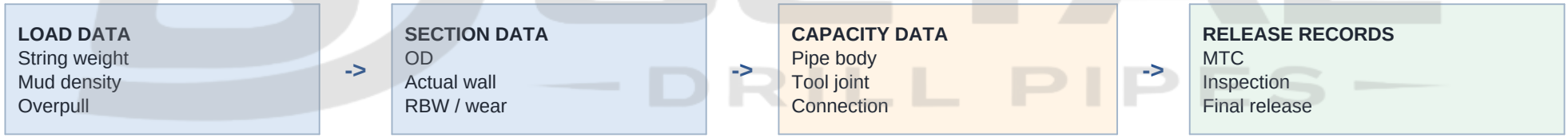
Grade Selection Rules

	Fix pipe geometry OD, actual wall thickness, remaining body wall and wear allowance.
	Build the upper-string load Buoyed string weight + planned overpull + dynamic allowance.
	Apply the project margin Use the approved design factor; do not assume a universal value.
	Compare capacities Check pipe body, tool joint, connection combined loading and elevator shoulder.
	Select the lowest compliant grade X95, G105 or S135 must retain adequate verified margin.

8. Verification Package and Final Release

The grade decision is complete only when load data, actual pipe dimensions and certified records refer to the same drill pipe.

Record / Check	Required Verification	Use in Upper-String Review
MTC	Grade, heat number, chemistry and mechanical properties.	Confirms the material basis for X95, G105 or S135.
Tensile report	Yield strength, tensile strength and elongation.	Confirms the tested strength window.
Dimensional inspection	OD, actual wall thickness, straightness and upset dimensions.	Provides the section used for capacity review.
Wall thickness result	Minimum measured wall and remaining body wall classification.	Prevents nominal wall from overstating capacity.
Tool joint inspection	Tool joint OD / ID, wear, shoulder and connection dimensions.	Confirms whether the assembly limit supports pipe-body load.
Thread and shoulder inspection	Gauge result, thread condition, shoulder contact and damage status.	Supports make-up torque and connection integrity.
NDT report	Pipe body, weld and transition-area defect inspection.	Confirms no rejectable indication reduces the intended load path.
Load calculation file	Air weight, mud weight, buoyancy, hook load, overpull and dynamic allowance.	Connects the operating case to the selected grade.



Final technical note: select X95, G105 or S135 from the verified load margin, not from measured depth alone. The approved capacity is the lowest applicable limit among pipe body, tool joint, connection, elevator shoulder and project design criteria.

Reference basis: API 5DP grade mechanical values; public 2025 performance data for 5.000 in x 19.50 lb/ft, 0.362 in wall, NC50 G105 and S135 drill pipe at Premium Class 80%; simplified section calculations are identified as screening calculations and do not replace certified product performance data.