API 5DP Drill Pipe Grade Selection Matrix for Deep and Directional Wells

Data-centered review of E75, X95, G105 and S135 using well profile, axial load, torque-drag, dogleg bending, fatigue, pipe dimensions, connection limits and inspection records.

Standard basis	Current API status	Selection principle
API Spec 5DP drill-pipe-body grades and drill pipe assembly requirements	2nd Edition (2020) with 2025 addenda and errata	Well profile -> load path -> grade range -> pipe / connection review -> records

1. API 5DP Grade Strength Baseline

Minimum yield strength ladder

Grade	Minimum Yield	Maximum Yield	Minimum Tensile	Yield Window	Min Yield vs E75
E75	75 ksi / 517 MPa	105 ksi / 724 MPa	100 ksi / 689 MPa	30 ksi / 207 MPa	Baseline
X95	95 ksi / 655 MPa	125 ksi / 862 MPa	105 ksi / 724 MPa	30 ksi / 207 MPa	+20 ksi / +26.7%
G105	105 ksi / 724 MPa	135 ksi / 931 MPa	115 ksi / 793 MPa	30 ksi / 207 MPa	+30 ksi / +40.0%
S135	135 ksi / 931 MPa	165 ksi / 1,138 MPa	145 ksi / 1,000 MPa	30 ksi / 207 MPa	+60 ksi / +80.0%

Engineering use: grade strength is applied to the actual remaining pipe-body section. For a selected OD and wall thickness, gross section area is A = pi/4 x (OD^2 - ID^2); nominal pipe-body yield load is Py = A x SMYS. Wear-reduced wall thickness must be used for field-condition review.

2. Deep Well vs Directional Well Load Matrix

Review Item	Deep Well	Directional / Horizontal Well	Engineering Output
Primary load	Buoyed string weight, hook load and planned overpull	Combined tension, torque, drag, side force and bending	Defines the governing load path
Critical well section	Upper drill string	Build / drop section, hold section and long lateral	Locates the first mechanical limit
Key model inputs	String weight, BHA weight, fluid density, overpull and dynamic allowance	Pick-up / slack-off load, rotating torque, sliding drag, friction factor, DLS and rotation time	Creates the load case used for grade screening
Primary capacity check	Pipe-body tensile load and tool joint tensile capacity	Pipe-body combined load, connection torque and fatigue-sensitive geometry	Separates pipe-body and connection limits
Main failure concern	Insufficient tensile margin or wall-loss derating	Cumulative fatigue, shoulder / thread stress and connection overload	Defines required inspection depth
Common initial range	G105 / S135	X95 / G105 / S135	Starting range only; not a fixed rule

Deep-well screening formulas

Calculated Item	Working Expression	How It Affects Grade Review
Required tensile design load	Buoyed string weight + planned overpull + project-defined dynamic allowance	Compared with allowable pipe-body and tool joint tensile load
Remaining tensile margin	Allowable tensile load - required tensile design load	Low remaining margin moves review from X95 toward G105 or from G105 toward S135
Wear-adjusted section	Use measured / specified remaining wall thickness in A = pi/4 x (OD^2 - ID^2)	Prevents grade selection from using nominal new-pipe capacity

No universal depth threshold: two wells at the same measured depth can require different grades because pipe size, wall thickness, BHA weight, mud density, overpull and connection capacity are different.

3. Grade Review Range by Well Condition

Well Condition	Specific Operating Detail	Initial Grade Range	Main Control Point	Next Review Trigger
Controlled medium-depth directional well	Moderate build / hold section, limited lateral length, controlled rotary torque and dogleg exposure	X95 / G105	Tensile margin, connection condition and moderate bending exposure	Move toward G105 when torque-drag or upper-string tension exceeds the X95 margin
Deep vertical or deviated well	Higher string weight, larger hook load, planned overpull and deeper upper-string loading	G105 / S135	Wear-adjusted tensile margin and tool joint tensile capacity	Review S135 when combined hook load and overpull reduce usable G105 margin
Long horizontal section	Extended lateral contact, high rotary time, accumulated torque-drag and repeated wall contact	G105 / S135	Torque utilization, fatigue exposure, shoulder / thread condition	Review S135 when long rotation and combined loading reduce G105 margin
ERD well	Extended measured depth with simultaneous high tension, torque, drag and connection-side loading	S135 / special material route	Combined load path, connection torque and fatigue life	Move beyond normal grade review when service, fatigue or connection limits control
Severe dogleg or high build rate	High curvature with repeated rotation through build / drop sections	Grade + fatigue review	DLS, bend cycles, upset transition and thread-root fatigue	Detailed fatigue assessment required before any grade upgrade
High-torque section	High make-up / rotary torque and repeated shoulder loading	G105 / S135	Connection rating, shoulder contact, thread condition and tool joint match	Higher pipe-body grade is valid only when the connection supports the same load

Grade boundary check

Boundary	Retain Lower Grade When	Review Higher Grade When
X95 -> G105	Calculated tension, torque and bending exposure remain inside the X95 pipe-body and connection margin	Directional load, torque-drag or tensile demand reduces the remaining X95 margin
G105 -> S135	G105 retains adequate wear-adjusted tensile margin and connection / fatigue demand is controlled	High hook load, long lateral rotation, ERD torque-drag or severe combined load reduces G105 margin
S135 -> Special route	Normal API grade, connection, toughness and service requirements remain sufficient	Sour service, low-temperature toughness, severe fatigue or special connection qualification governs the design

4. Key Control Points - Pipe Design and Connection

Control Point	Data to Confirm	Why It Changes Grade Selection	Typical Evidence
Pipe OD / wall thickness	Specified OD, actual wall, nominal weight, remaining wall after wear	Controls metal area, string weight, tensile load and internal clearance	Dimensional report, UT wall-thickness record
Wear allowance	Expected / measured wall loss and inspection class	Reduces remaining section and usable tensile margin	Field inspection report, wear map
Upset type	IU, EU or IEU geometry and transition profile	Changes internal bore, external clearance and fatigue-sensitive geometry	Drawing, dimensional inspection, drift test
Tool joint OD / ID	Tool joint size, bore, external clearance and tensile / torsional match	Can become the first limit in tension, torque or tool passage	Tool joint dimensional record
Connection torque	Connection type, make-up torque, modeled rotary torque and allowable torque	Higher pipe-body grade does not automatically increase connection torque capacity	Thread / shoulder inspection, torque basis
Fatigue-sensitive areas	Upset transition, friction weld, tool joint transition, thread root and shoulder	Local geometry and repeated bending can control life before pipe-body yield	MPI / UT / dimensional inspection

Connection and utilization checks

Review Ratio / Check	Expression or Comparison	Interpretation
Connection torque utilization	Modeled maximum rotary torque / allowable connection torque	Must remain within the project operating limit, including make-up and wear condition
Pipe-body tensile utilization	Required tensile design load / allowable wear-adjusted tensile load	Used to compare X95, G105 and S135 for the selected size and wall thickness
Grade-to-connection match	Pipe-body capacity compared with tool joint / shoulder / thread capacity	The lowest verified limit governs the assembly, not the highest grade number
Internal clearance check	Tool joint ID, upset ID and drift diameter vs tool / hydraulic requirement	A grade upgrade does not solve restricted bore or tool-passage limitations

Assembly rule: pipe body, upset transition, weld zone, tool joint and rotary shouldered connection must support the same load path. The lowest verified capacity controls the final grade decision.

5. Directional-Well Load Path and Fatigue Matrix

Well Section	Dominant Load	Required Data	Primary Risk	Grade Review Effect
Vertical section	Axial tension and hook load	Buoyed string weight, overpull, upper-string tension	Insufficient tensile margin	X95 / G105 / S135 by wear-adjusted capacity
Build / drop section	Tension plus repeated bending	Dogleg severity, build rate, rotation time, bend cycles	Upset / weld / connection fatigue	Grade plus fatigue-sensitive geometry review
Hold section	Tension, torque, drag and side force	Pick-up / slack-off load, rotating torque, friction factor	Connection and shoulder loading	G105 when controlled; S135 if combined load reduces G105 margin
Horizontal lateral	Sustained drag, rotation and contact	Lateral length, rotary time, torque accumulation, wear	Cumulative fatigue and abrasive wear	G105 / S135; ERD may require special route

Fatigue-sensitive location review

Location	Load Mechanism	Required Review
Pipe-body to upset transition	Repeated curvature and section-stiffness change	Profile geometry, wall transition, NDT and bend-cycle exposure
Friction weld / heat-affected zone	Local material and geometry transition under bending / torque	Weld inspection, hardness / impact data where required, fatigue history
Tool joint transition	Stiffness change and local contact under rotation	Tool joint geometry, wear, NDT and dimensional condition
Thread root / shoulder	Connection torque, shoulder compression and repeated cyclic load	Thread inspection, gauge result, shoulder contact and make-up basis

Directional-well rule: adequate axial strength does not close the review. Torque-drag, DLS, rotation time and connection condition can govern the selection even when pipe-body stress remains below yield.

6. Inspection and Documentation Matrix

Record Item	What It Verifies	Selection Relevance
Pipe marking	Grade, size, connection and product identity	Confirms the selected grade and dimensions belong to the delivered joint
Heat number + MTC	Chemical analysis and mechanical-property basis	Links grade strength to the production heat
Tensile test	Yield strength, tensile strength and elongation	Confirms the pipe-body grade window used in load calculations
Charpy / hardness where required	Toughness, heat-treatment consistency and cracking-risk control	Needed when low temperature, sour service or special material route governs
NDT report	Pipe body, weld zone and fatigue-sensitive defect inspection	Supports deep / directional service where cyclic loading is significant
Dimensional inspection	OD, wall thickness, straightness, upset and tool joint dimensions	Confirms remaining section and internal clearance assumptions
Thread / shoulder inspection	Thread profile, gauge result and shoulder contact	Confirms connection-side torque and load transfer basis
Final release record	Links all records to the released drill pipe	Closes traceability for the selected grade and configuration

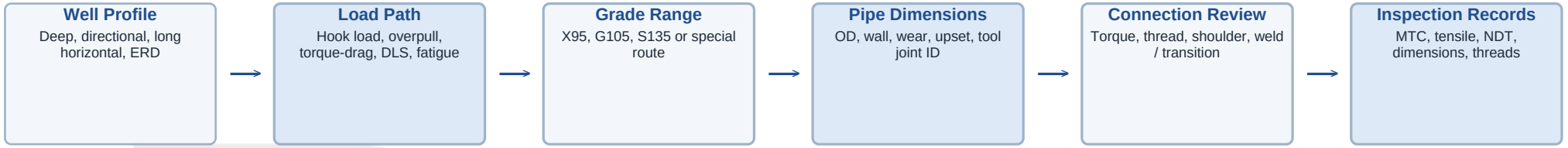
Traceability chain

1 Pipe marking	**2** Heat number	**3** MTC + tensile	**4** Charpy / hardness if required	**5** NDT + dimensions	**6** Tool joint / thread	**7** Final release

Record rule: a grade name is not a verified performance level unless the pipe marking, heat, mechanical tests, actual dimensions, connection inspection and final release refer to the same drill pipe.

7. Final Selection Flow

Use the workflow below to convert a well profile into a documented API 5DP grade decision. The flow is deliberately sequential: grade is not selected before the governing load and assembly limits are known.



Final decision matrix

Well Condition	Initial Grade Range	Governing Review	Final Confirmation
Controlled medium-depth directional well	X95 / G105	Tensile margin, torque and moderate dogleg bending	Connection capacity and tool joint condition
Deep well	G105 / S135	Buoyed string weight, hook load, planned overpull and remaining wall	Wear-adjusted tensile capacity and tool joint tensile limit
Long horizontal well	G105 / S135	Torque-drag, rotation time, cumulative fatigue and wear	Upset transition, shoulder contact and thread condition
Severe dogleg section	Grade + fatigue review	DLS, curvature, bend cycles and local transition stress	Transition-area NDT and connection inspection
ERD well	S135 / special material route	Combined tension, torque, drag, fatigue and connection load	Pipe body, tool joint and connection support the same load path

Selection note: the matrices define engineering review boundaries, not fixed grade rules. Final design requires the applicable API 5DP edition, project criteria, actual drill string configuration, torque-drag / fatigue model outputs and certified inspection records.

Technical basis: *API Spec 5DP, 2nd Edition (2020) with 2025 updates; API Spec 7-2; API RP 7G; and drillstring torque-drag, ERD and fatigue studies published through OnePetro.*
Prepared as a technical screening reference. It does not replace a project-specific drill string design calculation or the controlled copy of the applicable standard.