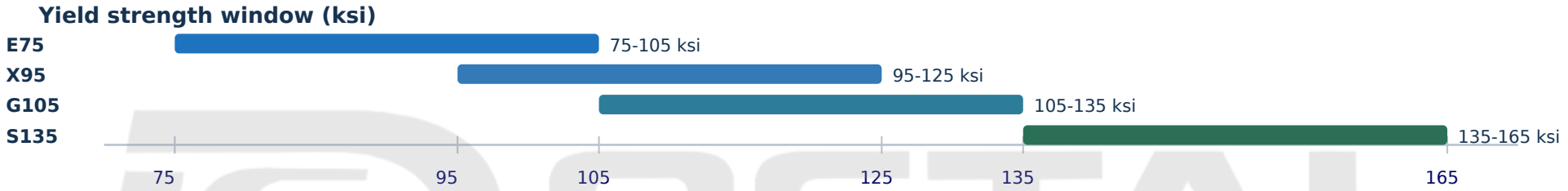
Standard API Drill Pipe vs Special Material Drill Pipe Performance Review

A data-based review of strength, toughness, hardness, fatigue behavior and tool-joint matching before a special material route is specified.

Many drill-pipe articles stop at API 5DP grade names. This reference sheet puts the standard API grade ladder together with the performance controls that become critical in special material drill pipe review: Charpy impact toughness, hardness, sour-service limits, fatigue-sensitive transition areas and tool-joint performance.



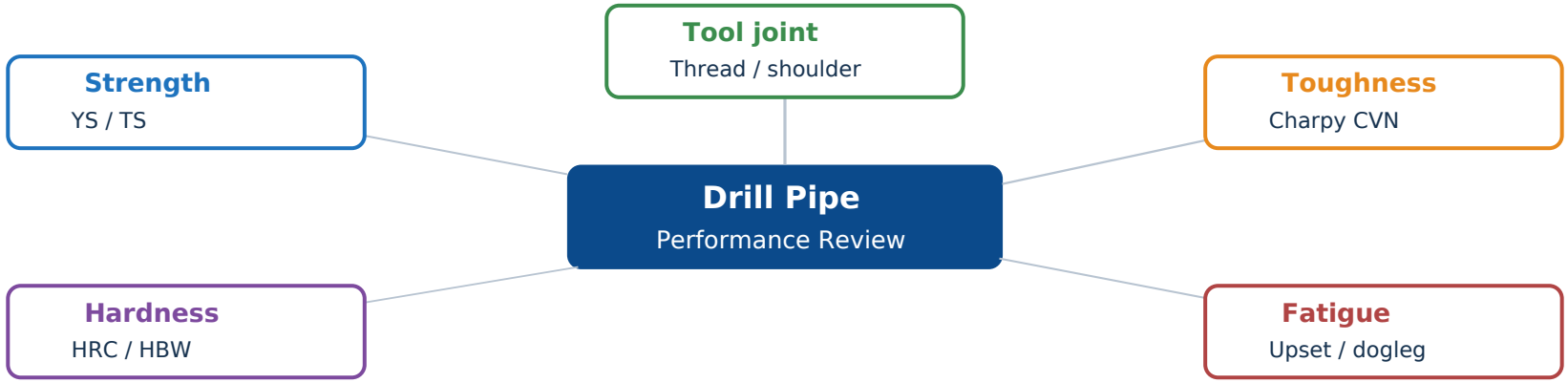
1. API 5DP standard grade strength ladder

Grade	Min Yield Strength	Max Yield Strength	Tensile Strength Range	Primary Review Meaning
E75	75 ksi / 517 MPa	105 ksi / 724 MPa	100-140 ksi / 689-965 MPa	Baseline strength for moderate drilling loads.
X95	95 ksi / 655 MPa	125 ksi / 862 MPa	105-145 ksi / 724-1000 MPa	Higher tensile margin for deeper or directional sections.
G105	105 ksi / 724 MPa	135 ksi / 931 MPa	115-155 ksi / 793-1069 MPa	High-strength API grade before S135 review.
S135	135 ksi / 931 MPa	165 ksi / 1138 MPa	145-185 ksi / 1000-1276 MPa	Common high-strength API baseline for demanding drill strings.

Key point: yield strength increases load capacity, but severe drilling conditions are not controlled by yield strength alone. Special material review starts when toughness, hardness, fatigue behavior or connection-side performance becomes the limiting factor.

2. Strength, toughness, hardness, fatigue and tool-joint review

Special Material Drill Pipe is best understood as a performance-control route. It does not replace API 5DP baseline review; it adds tighter control where standard grade strength is not the only concern.



Performance Area	Standard API Drill Pipe	Special Material Drill Pipe Review	Technical Trigger
Strength	Grade window such as E75 to S135; tensile data verified by MTC.	May use a higher or tighter strength window, but only with matching toughness and tool-joint review.	Deep wells, higher hook load, long measured depth.
Toughness	CVN is controlled by grade / PSL / project requirement.	CVN at required temperature becomes a key acceptance point; low-temperature values may control selection.	Cold-region drilling, high-strength pipe, impact-sensitive wells.
Hardness	Surface and weld-zone hardness limits are part of API 5DP review.	Hardness is tied more closely to heat treatment, sour service and cracking risk.	Sour gas / H2S, high strength, unstable heat treatment.
Fatigue	Standard design and inspection cover normal operating ranges.	Upset transition, dogleg cycling, rotation hours and stress concentration receive deeper review.	Long horizontal wells, severe dogleg, ERD.
Tool joint	Connection, shoulder, thread and tool-joint condition are inspected.	Tool-joint strength, hardness and shoulder/thread performance must match pipe body demand.	High torque, connection-side limitation, repeated make-up.

3. CVN impact toughness reference points

Product / Condition	Test Temperature	10 x 10 mm Min Average	10 x 10 mm Min Single	Why it matters
Drill pipe body - grades X, G, S, V (PSL-1)	21 °C ± 3 °C	54 J	47 J	Baseline CVN review for high-strength API pipe body.
Tool joint grades E, X, G, S, V (PSL-1)	21 °C ± 3 °C	54 J	47 J	Tool joint toughness is part of connection-side performance.
Weld zone - grades E, X, G, S, V (PSL-1)	21 °C ± 3 °C	16 J	11 J	Weld-zone toughness is not the same as pipe body toughness.
Special material route	Project-defined	Often stricter or lower-temperature	Project-defined	Needs datasheet + test report, not just a grade name.

4. Hardness, sour service and material-control data

Hardness links material condition with cracking sensitivity. In high-strength or sour-service review, hardness is evaluated together with chemistry, heat treatment, microstructure and service environment.

Control Point	API 5DP / Addendum Reference Data	Performance Meaning
Surface hardness - E, X, G, S	No hardness number shall exceed 37 HRC.	Prevents excessive hardening in standard grade bodies.
Surface hardness - V	No hardness number shall exceed 40 HRC.	Higher strength grade still needs hardness limit control.
SS grade surface hardness	Surface hardness shall not exceed 32 HRC.	Sour-service materials need tighter cracking-control review.
Weld-zone through-wall hardness	Mean hardness <=37 HRC for E, X, G, S; <=40 HRC for V.	Weld-zone hardness is a separate risk area from pipe body strength.
Non-SS tool joint box hardness	285 HBW to 341 HBW.	Connection-side hardness must remain within controlled window.
SS tool joint H2S test	493 MPa / 72 ksi threshold for 720 h under NACE TM0177 Method A.	Sour-service qualification requires test evidence, not strength data alone.

5. Material and heat-treatment controls

Material Item	Standard API Grade Route	Special Material Route Review
P / S residual control	Pipe body grade E: P <=0.030%, S <=0.020%; X/G/S/V: P <=0.020%, S <=0.015%.	Residual control becomes more critical where low-temperature toughness, sour service or fatigue sensitivity is involved.
SS grade chemistry	SS95/SS105 pipe body includes Mn 0.40-1.00%, Cr 0.90-1.30%, Mo 0.30-0.60%, C 0.25-0.35%, P <=0.015%, S <=0.010%.	Chemistry is tied to SSC resistance, hardness and heat-treatment response.
Heat treatment	Grade E may follow normalized/tempered or Q&T; routes; X/G/S are Q&T; in API 5DP references.	Heat treatment must support the target strength + toughness + hardness balance.
SS microstructure	Grain size 6 or finer and >90% martensite after quenching for SS grades.	Microstructure control becomes part of performance qualification.

6. Fatigue-sensitive zones and tool-joint controls

Fatigue and connection risk often start outside the basic yield-strength table. Upset geometry, transition areas, tool-joint alignment, thread condition and shoulder contact must be reviewed when the drill string works under combined tension, torque and cyclic bending.

Control Area	Useful Data / Review Point	Why it belongs in the performance review
Wall thickness	Pipe-body wall thickness shall not be less than specified thickness minus 12.5%, unless otherwise specified.	Wall loss affects load capacity and fatigue margin before grade strength is reached.
Straightness	Deviation from straightness: <=0.2% total length or <=3.2 mm drop in 1.5 m from each end.	Straightness affects rotation, bending and connection loading.
Tool-joint alignment	Parallel misalignment <=4 mm TIR; angular misalignment <=8 mm/m for 4-1/2 in and larger, <=10 mm/m for smaller sizes.	Poor alignment concentrates bending and connection-side stress.
Drift test	Mandrel at least 100 mm long; minimum diameter 3.2 mm smaller than specified pin-end ID.	Confirms internal passage through tool joints/upsets, but not full fatigue performance.
Upset transition	Automated inspection may require documented prove-up of transition areas not fully covered by systems.	Transition zones are fatigue-sensitive and deserve separate review in severe drilling.
Tool joint / thread	Thread, shoulder, OD/ID, hardness and connection condition reviewed together.	High torque and repeated make-up can make connection performance the limiting factor.

7. Records that prove the performance route

Record	API 5DP Baseline	Special Material Review Add-on
Pipe marking + heat number	Links product identity to grade and heat.	Connects special material route to actual pipe pieces.
MTC / chemical analysis	Reports heat/product chemistry and mechanical results.	Must support alloy design and performance target.
Tensile test	Yield, tensile strength and elongation.	Confirms the strength window, not only minimum strength.
Charpy impact test	Grade / PSL / project-based CVN data.	Often critical at lower temperature or higher strength.
Hardness record	Required where applicable by grade/service.	Tied to sour service, cracking risk and heat treatment.
NDT + dimensional reports	Supports pipe body, weld-zone and dimensional acceptance.	Needed to close fatigue and transition-zone risk.
Tool-joint / thread inspection	Connection, shoulder and thread condition.	Proves connection-side performance matches pipe body demand.

Traceability chain: Pipe marking -> Heat number -> MTC -> Tensile test -> Charpy impact test -> Hardness record -> NDT report -> Dimensional inspection -> Tool-joint/thread inspection -> Final release record.