1. Material and Heat Treatment - Selection Logic

Material grade should support the finished crossover geometry and service requirement, not replace them. Integral crossover subs concentrate load around the threaded ends, shoulders and reduced sections while maintaining an internal bore. Material selection therefore has to be considered together with connection geometry, section size and heat-treatment response.

4145H Modified Alloy Steel

Common alloy-steel option for integral crossover and rotary-sub construction. Its usefulness depends on the specified heat-treated condition and finished section geometry.

4140-Series Alloy Steel

Used in some crossover/sub designs where the material, connection and finished dimensions are specified accordingly. It should not be treated as interchangeable with 4145H by name alone.

Quenched and Tempered Condition

A controlled heat-treatment route used to develop the required balance of strength and toughness in heat-treatable alloy steel. Final acceptance is based on the specified material condition and properties.

Material boundary

4145H is a common material option, not a universal requirement for every crossover sub. Final material selection should be tied to the connection design, finished dimensions, heat-treatment condition and service basis.

Material selection drivers

Design driver	Why it matters	What to verify
Connection / shoulder geometry	Threads and shoulders are concentrated load-transfer features.	Specified connection, finished section dimensions and compatible material condition.
Section thickness / body profile	Heat-treatment response must be suitable across the finished section.	Material condition and mechanical-property basis for the finished size.
Internal bore	The bore reduces section area and defines the fluid passage.	Bore size/alignment against the approved design.
Service basis	Service may add material, hardness or examination requirements.	Project/product specification before production release.

2. Integral Crossover Sub Manufacturing Route

The value of the manufacturing route is not the list of operations by itself, but the control objective at each stage. The sequence below shows how material identity, geometry and connection accuracy are progressively locked into the finished sub.

1 Material Identification

Confirm material identity and traceability before irreversible processing.

Control: Risk if missed: wrong alloy or lost traceability.

2 Heat Treatment

Establish the specified material condition before final connection geometry is released.

Control: Risk if missed: properties or distortion outside the design basis.

3 OD / Body Machining

Create the finished external profile and establish reference geometry for both ends.

Control: Risk if missed: external interference or inconsistent end relationship.

4 Bore Machining

Produce the required internal passage and maintain bore alignment through the body.

Control: Risk if missed: unintended flow restriction or eccentric wall section.

5 Upper / Lower Connection Machining

Machine each end independently to its specified pin or box connection.

Control: Risk if missed: connection mismatch at one side of the crossover.

6 Thread & Shoulder Finishing

Control thread profile and shoulder surfaces required for proper make-up.

Control: Risk if missed: poor shoulder contact, galling tendency or unstable make-up.

7 Gauging / Dimensional Verification

Confirm connection geometry and finished dimensions against the applicable basis.

Control: Risk if missed: visually correct threads that do not meet the required connection geometry.

8 Final Verification / Protection

Close traceability, required inspection records, marking and connection protection.

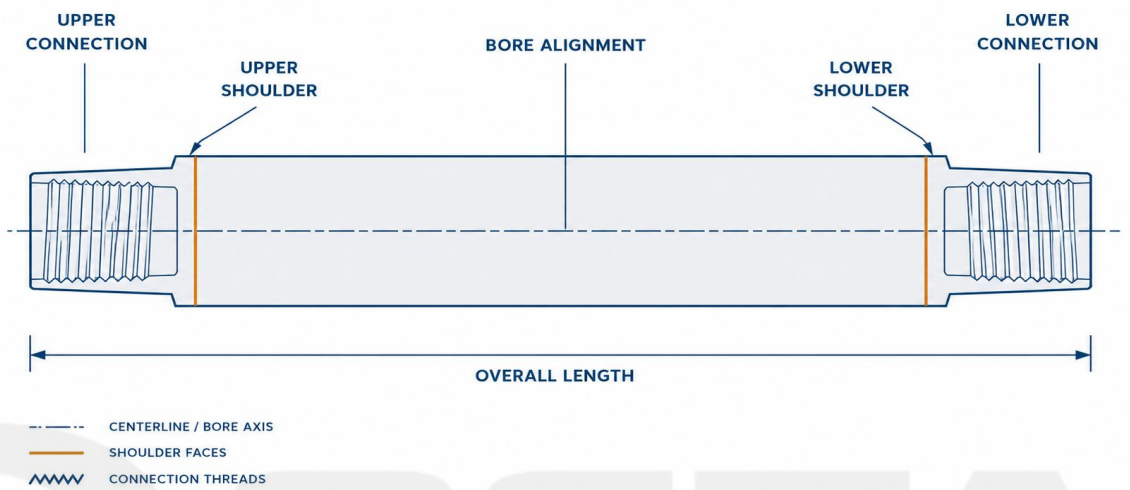
Control: Risk if missed: incomplete release basis or handling damage after machining.

Manufacturing release principle

Do not release the finished sub from machining based on thread appearance alone. The two end connections, shoulder geometry, OD, bore and overall length must resolve to one internally consistent finished drawing and inspection record.

3. Critical Manufacturing Control Areas

The diagram below identifies the areas that most directly affect fit, make-up and fluid passage. It is a generic control schematic - the actual connection profiles and dimensions must come from the specified product drawing.



Control area	Why it matters	Release question
Upper / lower connection	Each end can be a different connection; both must be correct.	Does each end match the actual mating component?
Thread + shoulder	Together they determine proper make-up geometry and load transfer.	Are thread form, gauging and shoulder surfaces consistent with the specified connection?
Bore alignment	Defines the uninterrupted internal passage through the sub.	Is the bore size/alignment compatible with the required fluid path?
OD / body profile	Controls external clearance and remaining wall section.	Does the finished profile suit the adjacent string geometry?
Overall length	Controls tool spacing and assembly fit.	Does the finished length match the approved assembly layout?

4. Final Inspection Reference - Evidence Before Release

Final inspection should answer a simple question: can the finished crossover be traced, identified and shown to match the specified connection and dimensional basis? The checklist below separates universal verification items from requirement-dependent examination.

Verification area	What should be confirmed	Typical release evidence	Status
Material traceability	Material identity and link to the finished component.	Material/heat identification record or equivalent traceability record.	**Core**
Connection identification	Exact upper and lower connection designations and pin/box orientation.	Drawing, route card or final inspection record.	**Core**
Thread gauging	Connection geometry conforms to the applicable gauging basis where standardized connections are used.	Gauge/inspection record linked to each end.	**Core for gauged standard connections**
OD / bore / length	Finished dimensions match the approved product geometry.	Dimensional inspection record.	**Core**
Shoulder condition	Shoulder surface and geometry are suitable for intended make-up.	Visual/dimensional inspection record as applicable.	**Core**
NDT	Specified product areas meet the required examination method and acceptance basis.	NDT report when required.	**Requirement-dependent**
Marking / protection	Finished part is correctly identified and machined connections are protected.	Final visual release check.	**Core**

API connection control

API Spec 7-1 covers rotary drill stem elements such as drill stem subs. API Spec 7-2 separately addresses threading and gauging of rotary shouldered connections. Product and connection requirements should therefore be reviewed together.

NDT boundary

Do not assume one NDT package applies to every crossover sub. Examination method, coverage and acceptance criteria should be defined by the applicable product requirement or service condition.

Release rule

Release only when the physical part, connection identity, finished dimensions and supporting records describe the same final configuration.