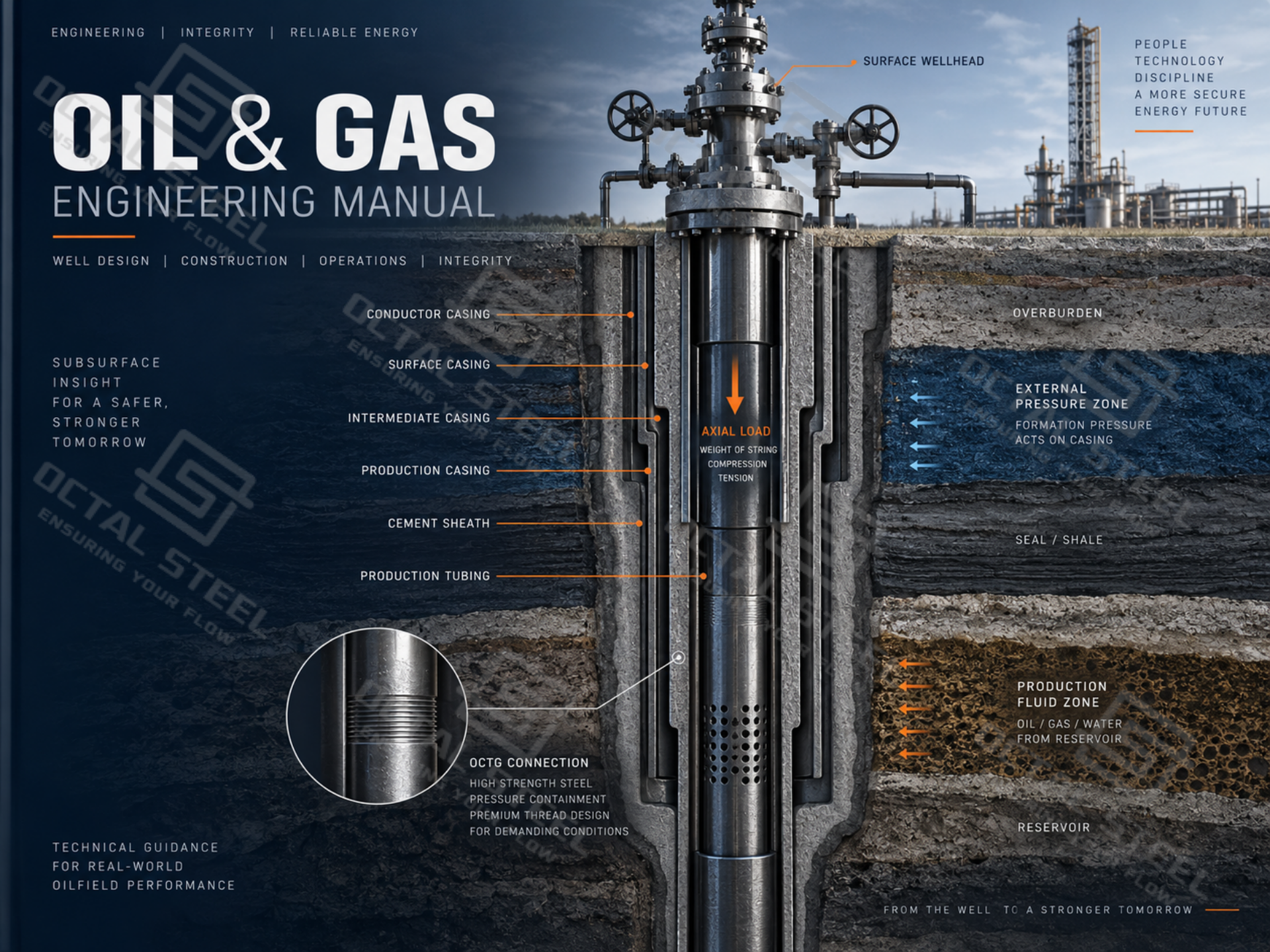
ENGINEERING | INTEGRITY | RELIABLE ENERGY

OIL & GAS
ENGINEERING MANUAL

WELL DESIGN | CONSTRUCTION | OPERATIONS | INTEGRITY

SUBSURFACE
INSIGHT
FOR A SAFER,
STRONGER
TOMORROW



PEOPLE
TECHNOLOGY
DISCIPLINE
A MORE SECURE
ENERGY FUTURE

TECHNICAL GUIDANCE
FOR REAL-WORLD
OILFIELD PERFORMANCE

FROM THE WELL TO A STRONGER TOMORROW

OCTG MATERIAL SELECTION LOGIC

CASING AND TUBING FOR OIL AND GAS WELLS

RIGHT MATERIAL.
SAFER WELLS.
LONGER LIFE.

RESERVOIR
WELL
FACILITIES
PRODUCTION

WELL FUNCTION

Conductor Casing
(shallow, unstable formations)

Surface Casing
(isolation, fresh water protection)

Intermediate Casing
(pressure / pore pressure control)

Production Casing
(reservoir isolation)

Tubing
(production / injection)

DOWNHOLE CHEMISTRY

Typical Fluid Components	Range (typical)
CO_2	0 – 20 mol%
H_2S	0 – 5 mol%
Chloride (Cl^-)	0 – 250,000 ppm
pH	3 – 8
Dissolved Oxygen	0 – 50 ppb
Scaling Ions (Ca^{2+}, Ba^{2+}, Sr^{2+})	Variable
Treatment Chemicals	Various

Evaluate corrosion, scaling and MIC risk (NACE MR0175 / ISO 15156).

MATERIAL ROUTE

Common OCTG Grades (API 5CT)

Grade	Typical Use
J55	Shallow, low load
K55	General service
N80 / L80	Moderate to high load
C90	High load, deep wells
P110	HP/HT, severe service
CRA / Alloy	Corrosive / sour environments

Select grade, connection type and corrosion resistance per well design.

1 Well Function

Casing or Tubing?
Section (conductor, surface, intermediate, production)?
HP/HT, sour service, completion type?

2 Mechanical Load

Internal / external pressure
Tension, compression, bending
Collapse, burst, tensile limits (API 5C3 / ISO 11960)

3 Downhole Chemistry

CO_2, H_2S, chlorides, pH
Sour service (NACE MR0175 / ISO 15156)
Scaling potential, oxygen, treatment chemicals

4 Material Route

Select steel grade (e.g., J55, K55, N80, P110)
Assess corrosion resistance (CRA / alloy / clad)
Define connections and additional requirements

5 Inspection

Verify material traceability
Dimensional and non-destructive testing
Confirm to API 5CT and purchase specification

MECHANICAL LOAD

Key Mechanical Considerations	
Internal Pressure	Burst
External Pressure	Collapse
Axial Load	Tension / Compression
Bending	Dogleg, well deviation
Combined Loading	Triaxial design
Design Standard	API 5C3 / ISO 11960

Verify design factors for static and dynamic loading conditions.

TEMPERATURE

Downhole Temperature Impacts

- Affects material strength and toughness
- Influences corrosion rate and chemistry
- Consider HT service (e.g., > 150 °C)
- Verify material limits and sealing capability

Typical Range:
50 – 200 °C (deeper wells can exceed 250 °C)

CORROSION

General Corrosion
(uniform wall loss)

Localized Corrosion
(pitting / SSC risk)

Corrosion Mechanisms

- CO_2 corrosion (carbonic acid)
- H_2S (sour service / SSC)
- Chloride-induced pitting
- MIC (microbiologically influenced)
- Erosion-corrosion (high velocity)

INSPECTION

Inspection Requirements

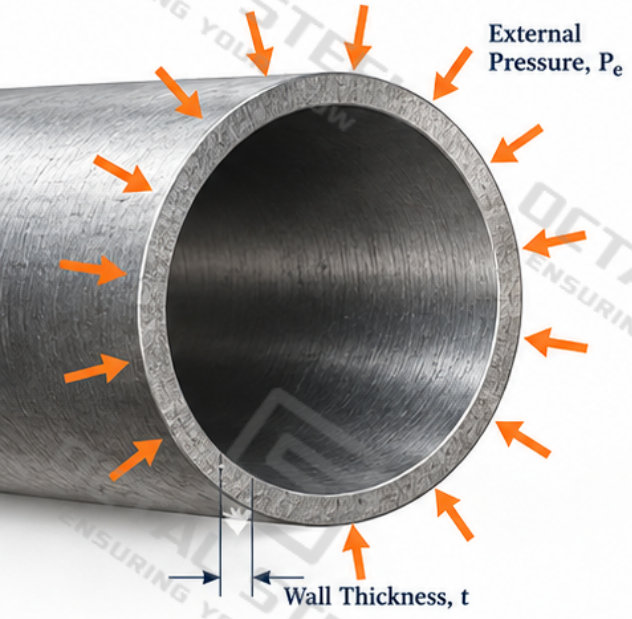
- Verify mill test certificates (MTC)
- Dimensional inspection (OD, ID, wall thickness, length)
- Non-destructive testing (UT, EMT, visual)
- Thread and connection inspection
- Compliance with API 5CT and purchase specification

MECHANICAL LOADING OF CASING PIPE

PRIMARY DESIGN CONSIDERATIONS FOR OCTG IN DOWNHOLE ENVIRONMENTS

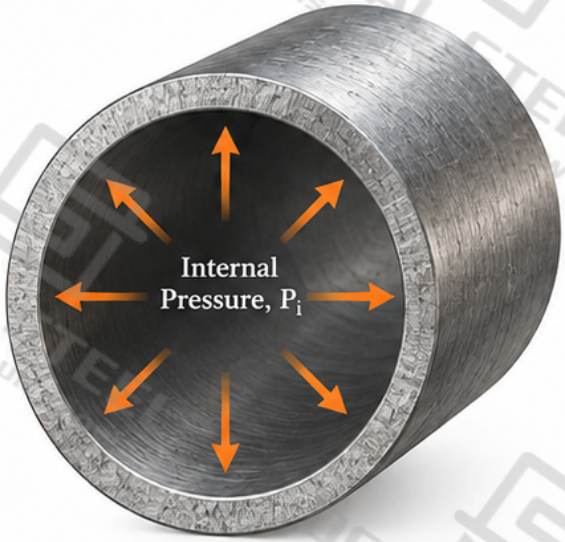
1 Collapse Resistance

EXTERNAL PRESSURE
RESISTS RADIAL INWARD LOADING



2 Internal Pressure Resistance

INTERNAL PRESSURE
RESISTS RADIAL OUTWARD LOADING



3 Axial Load Capacity

AXIAL TENSION AND COMPRESSION
RESISTS LONGITUDINAL LOADING

COLLAPSE RESISTANCE (EXTERNAL PRESSURE)

$$P_c = \frac{2E}{\sqrt{3(1-\nu^2)}}\left(\frac{t}{D}\right)^3$$

P_c = collapse pressure (external), psi
E = Young's modulus, psi
ν = Poisson's ratio
t = wall thickness, in
D = outside diameter, in

INTERNAL PRESSURE RESISTANCE (BURST)

$$P_b = \frac{2S_y t}{D - t}$$

P_b = burst pressure (internal), psi
S_y = yield strength, psi
t = wall thickness, in
D = outside diameter, in

AXIAL LOAD CAPACITY

Tension: $T = A\,S_y$

Compression: $C = A\,S_c$

T = tensile capacity, lbf
C = compressive capacity, lbf
A = cross-sectional area, in^2
S_y = yield strength (tension), psi
S_c = compressive strength (consider buckling), psi

WELL DESIGN
MATERIALS SELECTION
INTEGRITY MANAGEMENT

API 5CT OCTG Grade Selection Engineering Map

ENGINEERING ROUTES FOR CASING AND TUBING APPLICATIONS

SELECT GRADE FAMILY BASED ON APPLICATION CONDITIONS, NOT A RANKING

API 5CT
OIL COUNTRY TUBULAR GOODS
TECHNICAL REFERENCE
ENGINEERING APPLICATION

DIFFERENT APPLICATION CONDITIONS REQUIRE DIFFERENT OCTG SOLUTIONS

API 5CT grade families provide engineering routes to meet the mechanical, environmental and operational demands of a well.
Selection is based on detailed assessment of loading, temperature, sour service, corrosive environment and life-of-well requirements.

J55 / K55	N80	L80	T95 / C110	P110	C125 / Q125
CONVENTIONAL SERVICE ROUTE GENERAL PURPOSE WELLS	**INTERMEDIATE STRENGTH ROUTE** DEEPER / HIGHER LOAD APPLICATIONS	**ENHANCED PERFORMANCE ROUTE** DEMANDING ENVIRONMENTS	**HIGH STRENGTH ROUTE** HIGH LOAD, HIGH TEMPERATURE	**ULTRA HIGH STRENGTH ROUTE** EXTREME DEPTH AND SEVERE SERVICE	**EXTENDED CAPABILITY ROUTE** ULTRA-DEEP, HPHT AND CORROSIVE
					
Typical Use Shallow to moderate depth wells with conventional loading and environments.	**Typical Use** Moderate to deep wells with increased mechanical demands (e.g. higher collapse, burst or tensile loads).	**Typical Use** Wells with higher loads and/or more severe environments, including many sour service applications.	**Typical Use** Deep and ultra-deep wells with high mechanical loads and elevated temperature applications.	**Typical Use** Ultra-deep wells, high pressure / high temperature (HPHT) and severe mechanical loading conditions.	**Typical Use** Ultra-deep, HPHT and highly corrosive environments where maximum mechanical capability and enhanced environmental performance are required.
Mechanical Load Moderate. Suitable for conventional axial, burst and collapse requirements.	**Mechanical Load** Higher than J55/K55. Suited for increased axial, burst and collapse requirements.	**Mechanical Load** Similar to N80 with enhanced performance characteristics.	**Mechanical Load** High. Designed for increased axial, burst and collapse temperatuets in demanding wells.	**Mechanical Load** Very high. For extreme axial, burst and collapse demands.	**Mechanical Load** Very high. For the most demanding axial, burst and collapse conditions.
Heat Treatment Normalized.	**Heat Treatment** Normalized.	**Heat Treatment** Quenched and tempered.	**Heat Treatment** Quenched and tempered.	**Heat Treatment** Quenched and tempered.	**Heat Treatment** Quenched and tempered with controlled properties.
Sour Service Qualification Typically not qualified for sour service. Use as per API 5CT / NACE requirements.	**Sour Service Qualification** N80 (Type 1) not qualified. N80 (Type Q) qualified for sour service (per API 5CT and NACE).	**Sour Service Qualification** L80 (Type 1) not qualified. L80 (Type 9Cr) qualified for sour service (per API 5CT and NACE).	**Sour Service Qualification** T95: not qualified for sour service. C110: qualified for sour service (per API 5CT and NACE).	**Sour Service Qualification** P110 (Type 1) not qualified. P110 (Type Q) qualified for sour service (per API 5CT and NACE).	**Sour Service Qualification** C125: qualified for sour service. Q125: qualified for sour service (per API 5CT and NACE).
Corrosion Resistance Used with appropriate corrosion allowance and protective measures.	**Corrosion Resistance** Used with appropriate corrosion allowance and protective measures.	**Corrosion Resistance** Improved resistance relative to carbon steels. Used with additional CRA or coating as required.	**Corrosion Resistance** Good resistance for many environments. Used with additional corrosion protection as required.	**Corrosion Resistance** Used with appropriate corrosion allowance and additional protection (CRA, coatings, inhibitors) as required.	**Corrosion Resistance** Enhanced metallurgy for severe environments. Used with additional CRA, coating or other measures as required.

KEY CONSIDERATIONS FOR GRADE SELECTION

- Downhole mechanical loads (axial, burst, collapse, combined loading)
- Temperature and pressure profile
- Sour service requirements (H_2S) per API 5CT and NACE
- Corrosive environment (CO_2, chlorides, organic acids, etc.)
- Well architecture and operational constraints
- Required life and integrity management strategy
- Compatibility with completion fluids and interfaces
- Applicable industry standards and company specifications

API 5CT
MATERIAL SELECTION
SUPPORTS WELL INTEGRITY

ENG-5CT-001
REV 1.0
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SOURCE: API 5CT, NACE STANDARDS, AND INDUSTRY ENGINEERING PRACTICE

FIT FOR PURPOSE. DRIVEN BY APPLICATION.