CHAPTER III: STEEL PIPELINES

With reference to FFA (2012), steel is an iron-carbon alloy containing less than 2% carbon and other elements. The iron in steel comes either from ore or from recycling. As in other developed countries, the steel produced in France contains, on average, slightly more than half recycled iron. In emerging countries such as Brazil or China, steel is mainly produced from ore due to insufficient recycling. To transform cast iron into steel, it is sufficient to remove the excess carbon by burning it with oxygen. The chemical composition of the liquid steel obtained by smelting or fusion must then be adjusted according to the desired implementation and usage characteristics.

The liquid steel is then solidified, typically into a massive form, and subsequently shaped, usually by hot rolling and possibly by cold rolling, into thin sheets and the thinnest plates (Figure III.1 and Figure III.2).

Figure III.1. Hot Rolling of Strip (on the ground, rolls awaiting use) (FFA, 2012)

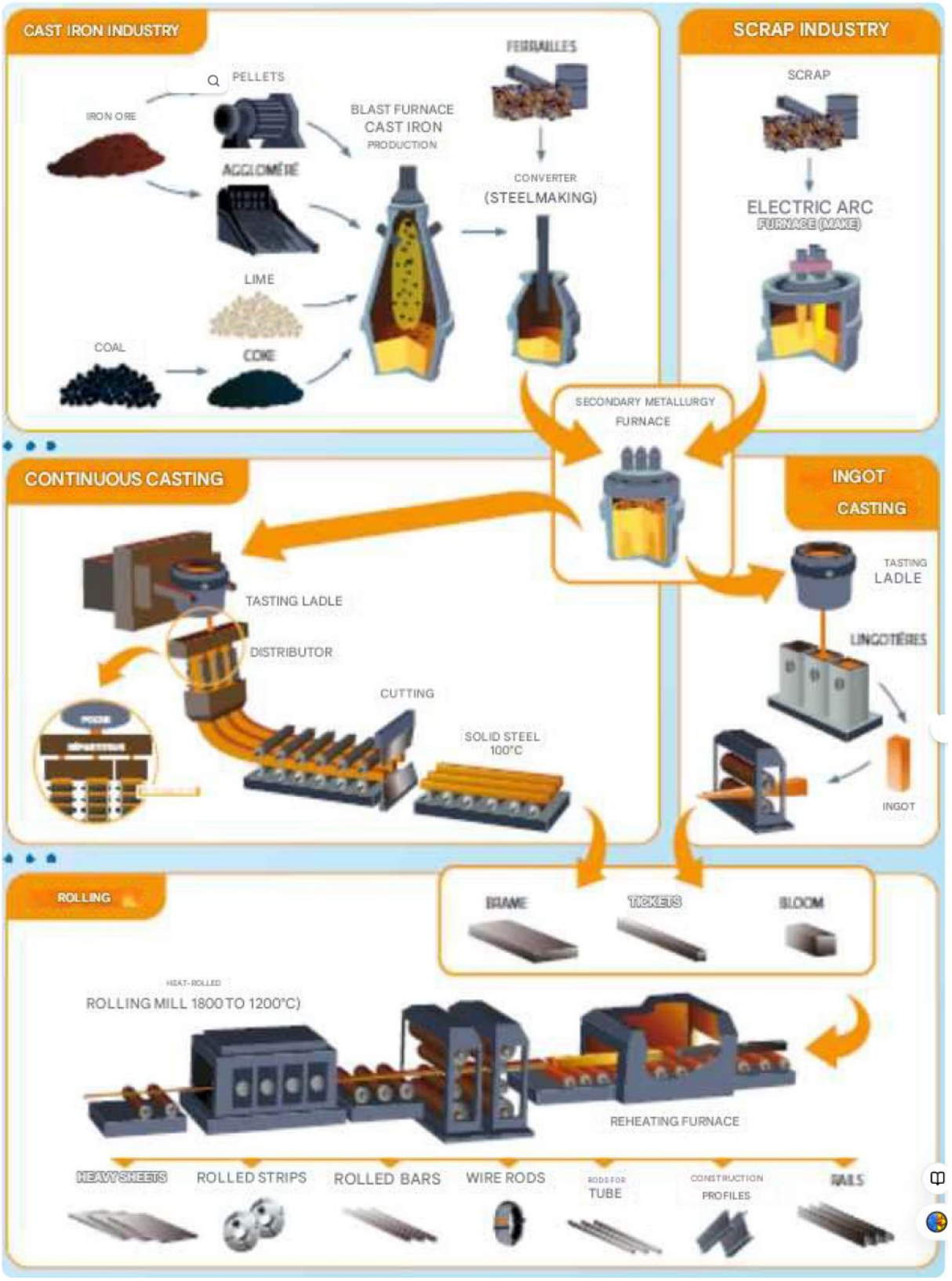

Figure III. 2. Steel transformation process (FFA, 2012).

III.1. Characterization

The steel used for manufacturing pipes is a weldable, low-carbon steel. The pipes can be produced by hot rolling without seams, through the progressive transformation of a single piece of metal using multiple passes on a mandrel (up to a diameter of 400 mm), or by longitudinal arc welding of formed plates (starting from a diameter of 350 mm), or from coiled strip (from 0.150 m to 600 mm in diameter). Steel pipes are available in lengths ranging from 6 m to 16 m and thicknesses from 3 mm to 9 mm. The pipes are factory-tested at pressures of 40 bar to 60 bar (Dupont, 1979).

Steel pipes can be used with various internal diameters in different installations: tanks, pumping stations, to overcome specific obstacles such as siphons, or for bridge access. Welded steel pipes are suitable for contaminated soils. They are particularly suited for high pressures, PN ≥ 1.6 MPa. In self-supporting sections and in galleries, steel pipes are supported or rested on blocks.

In urban, developable areas, steel pipes must be encased in a concrete layer with a square cross-section of side ≥ (Dext + 50 cm) to protect the concrete layer, reinforced with steel on all faces, designed to withstand rolling loads as well as the weight and thrust of the soil. Steel pipes without external coating must be protected by cathodic protection systems.

In all cases, the thickness-to-diameter ratio exceeds eight thousandths (8‰). The steels used in manufacturing are of the non-alloy type, as indicated by the EN 10020:2001 standard. The pipes are manufactured by rolling and welding, from longitudinally bent mild steel plates, by electric welding or from continuous strips coiled helically.

The pipes are finished at the ends, either by:

− Two plain ends for butt-welded assemblies;

− Or one plain end and one tulip-shaped, flared end assembled by a slip joint and overlap welding;

− Or one plain end and one tulip-shaped end with elastomeric joints or automatic assembly.

The standardized dimensions of steel pipes (diameters and thicknesses) vary according to the standard governing the product used: EN 10224:2003, DIN 1626:1984, or API 5L:2000.

For bare steel, which is the element most exposed to corrosion, the protection threshold is set at 100 Ohm-meters. Steel pipes must be internally coated with corrosion protection in the form of a 500-micron layer of food-grade epoxy paint, with prior surface preparation (Figure III.3).

If the pipes are not installed encased in concrete, they must be externally protected with a minimum layer of 400 microns of epoxy paint or a 3 mm layer of polyethylene (Veolia, 2009)

Figure III. 3. Externally coated steel (Veolia, 2009).

Steel pipes can be supplied with different types of joints, the most common of which are rigid assemblies:

• **Welded joint**: The preparation and welding of the joints must be carried out in accordance with EN 288:1993, by a welder qualified according to EN 287:1992 (Figure III.4).

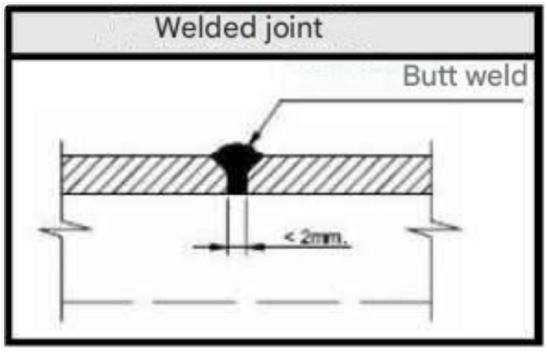

Figure III. 4. Welded Joint (Veolia, 2009)

The assembly welds of steel pipes are considered defective and unacceptable if they do not comply with the quality standards and tolerances for Class III welds as defined by the Syndicat National de la Chaudronnerie - Tôlerie in its Project No. 7 on weld classification. At any time, a qualified organization may perform radiographic, ultrasonic, or other inspections on the welds carried out by the contractor. Welded steel pipes are suitable for polluted soils. Steel pipes without external coating are protected by a cathodic protection system.

• **Flanged joint**: This type of joint is most commonly used for small-diameter pipelines in various installations: tanks, pumping stations, water treatment plants, etc. However, other types of joints can be used, such as sleeve joints.

The assembly with flanges must meet the following conditions:

• Ensure the continuity of the pipeline without risk of breakage or disconnection (the pipeline will be considered self-restrained);

• Ensure leak tightness;

• Ensure the continuity of internal and external coatings to avoid any preferential corrosion zones

Table III. 1. Bare Steel

NPS (inch)	OD (mm)	Weight/m	SCH20	SCH30	STD	SCH40	SCH60	SCH80	SCH100	SCH120	SCH140
1/8	10,3	WT			1,73	1,73		2,41			
		Kg/m			0,37	0,37		0,47			
1/4	13,7	WT			2,24	2,24		3,02			
		Kg/m			0,63	0,63		0,8			
3/8	17,1	WT			2,31	2,31		3,2			
		Kg/m			0,84	0,84		1,1			
1/2	21,3	WT	2,03		2,77	2,77		3,73			
		Kg/m	0,96		1,27	1,27		1,62			
3/4	26,7	WT	2,31		2,87	2,87		3,91			
		Kg/m	1,39		1,69	1,69		2,2			

1	33,4	WT	2,62		3,38	3,38		4,55			
		Kg/m	1,99		2,5	2,5		3,24			
1-1/4	42,2	WT	2,87		3,56	3,56		4,85			
		Kg/m	2,78		3,39	3,39		4,47			
1-1/2	48,3	WT	2,92		3,68	3,68		5,08			
		Kg/m	3,27		4,05	4,05		5,41			
2	60,3	WT	3,2		3,91	3,91		5,54			
		Kg/m	4,51		5,44	5,44		7,48			
2-1/2	73	WT	4,5		5,16	5,16		7,01			
		Kg/m	7,6		8,63	8,63		11,4			
3	88,9	WT	4,58		5,49	5,49		7,62			
		Kg/m	9,52		11,3	11,3		15,3			
3-1/2	102	WT	4,62		5,74	5,74		8,08			
		Kg/m	11,09		13,6	13,6		18,6			
4	114	WT	5,03		6,02	6,02		8,56		11,1	
		Kg/m	13,52		16,1	16,1		22,3		28,3	
5	141	WT	5,25	5,61	6,55	6,55		9,53		12,7	
		Kg/m	17,57	18,73	21,8	21,8		31		40,3	
6	168	WT	5,64	6,32	7,11	7,11		11		14,3	
		Kg/m	22,58	25,2	28,3	28,3		42,6		54,2	
8	219	WT	6,31	7,11	8,18	8,18	10,3	12,7	15,1	18,3	20,6
		Kg/m	33,1	37,15	42,6	42,6	53,1	64,6	75,9	90,4	101
10	273	WT	6,58	8,03	9,27	9,27	12,7	15,1	18,3	21,4	25,4
		Kg/m	43,23	52,47	60,3	60,3	81,5	96	115	133	155
12	324	WT	7,11	8,81	9,53	10,3	14,3	17,5	21,4	25,4	28,6

		Kg/m	55,56	68,48	73,9	79,7	109	132	160	187	208
14	356	WT	8,02	10	9,53	11,1	15,1	19,1	23,8	27,8	31,8
		Kg/m	68,82	85,32	81,3	94,6	127	158	195	225	254
16	406	WT	8,78	11,3	9,53	12,7	16,7	21,4	26,2	31	36,5
		Kg/m	86	109,99	93,3	123	160	204	246	287	333

NPS (inch)	OD (mm)	Poids/m	SCH20	SCH30	STD	SCH40	SCH60	SCH80	SCH100	SCH120	SCH140
1/8	10,3	WT			1,73	1,73		2,41			
		Kg/m			0,37	0,37		0,47			
1/4	13,7	WT			2,24	2,24		3,02			
		Kg/m			0,63	0,63		0,8			
3/8	17,1	WT			2,31	2,31		3,2			
		Kg/m			0,84	0,84		1,1			
1/2	21,3	WT	2,03		2,77	2,77		3,73			
		Kg/m	0,96		1,27	1,27		1,62			

NPS (inch)	OD (mm)	Poids/m	SCH20	SCH30	STD	SCH40	SCH60	SCH80	SCH100	SCH120	SCH140
1/8	10,3	WT			1,73	1,73		2,41			
		Kg/m			0,37	0,37		0,47			
1/4	13,7	WT			2,24	2,24		3,02			
		Kg/m			0,63	0,63		0,8			
3/8	17,1	WT			2,31	2,31		3,2			
		Kg/m			0,84	0,84		1,1			

1/2	21,3	WT	2,03	2,77	2,77	3,73
		Kg/m	0,96	1,27	1,27	1,62

Table III. 2. Bare Steel (DN 114.3 - 914 mm)

DN EXT. (MM)	EP (MM)	STOCK	DN EXT. MM	EP (MM)	STOCK
114,3	3,20	OUI	323,9	5,60	**OUI**
	4,00	OUI		6,30	**OUI**
	4,50	OUI		6,40	**OUI**
	4,80	OUI		7,10	**OUI**
	6,30	OUI		8,00	**OUI**
	7,10	OUI		8,38	**OUI**
168,3	4,50	OUI	355,6	5,00	**OUI**
	4,80	OUI		5,60	**OUI**
	5,16	OUI		6,30	**OUI**
	7,10	OUI		6,35	**OUI**
	7,11	OUI		6,60	**OUI**
	8,00	OUI		6,80	**OUI**
	8,80	OUI		7,10	**OUI**
216,8	8,00	OUI		8,00	**OUI**
219,1	5,60	OUI	406,4	5,60	**OUI**
	6,30	OUI		6,30	**OUI**
	7,04	OUI		6,50	**OUI**
	7,10	OUI		6,80	**OUI**
	8,00	OUI		7,10	**OUI**

	8,20	OUI		7,92	**OUI**
	9,53	OUI		8,00	**OUI**
273	5,00	OUI		8,70	**OUI**
	5,60	OUI		8,80	**OUI**
	6,30	OUI		9,20	**OUI**
	6,35	OUI	508	5,00	**OUI**
	6,40	OUI		8,80	**OUI**
	6,60	OUI	609	5,60	**OUI**
	7,10	OUI		7,10	**OUI**
	8,00	OUI	711	6,30	**OUI**
	8,80	OUI	812	7,80	**OUI**
	9,30	**OUI**	914	**7,10**	**OUI**

III.2. Application: Casing - Drilling

III.2.1. API 5CT Steel: Seamless – Welded

III.2.1.1. Short or Long Thread Type

The tube is threaded at both ends; the tubes are connected to each other using a coupling. According to API specifications, there are two types of threading with corresponding couplings: short or long. Casing tubes with long threading can transmit higher axial loads than those transmitted by tubes with short threading (Table IV.7).

III.2.1.2. Buttress Thread Type

The connection principle is the same as that of the "round thread." Instead of the "round thread," there is a "buttress" thread type that allows the transmission of very high axial loads (Table IV.7).

Table III. 3. Dimensions of API 5CT Steel Casing

DIMENSION		TUBE THICKNESS		THEORETICAL WEIGHT KG/m	PRESSURE TESTS				CONNECTION type		
OD Inch	OD mm	Thickness inch	Thickness mm	Plain End	H40		J55		H40	J55	L80
					PSI	BAR	PSI	BAR			
2 3/8	60,32	0,167	4,24	5,87	4500	310	6200	425	PN	PN	PN
		0,190	4,83	6,61	5100	355	7000	485	PNU	PNU	PNU
		0,254	6,45	-	-	-	-	-	-	-	PNU
		0,295	7,49	-	-	-	-	-	-	-	P
		0,336	8,53	-	-	-	-	-	-	-	PU
		0,217	**5,51**	9,17	4800	335	6600	460	PNU	PNU	PNU
		0,276	**7,01**	-	-	-	-	-	-	-	PNU
		0,308	**7,82**	-	-	-	-	-	-	-	PNU
		0,340	**8,64**	-	-	-	-	-	-	-	PU
		0,392	**9,96**	-	-	-	-	-	-	-	P
		0,440	**11,18**	-	-	-	-	-	-	-	P
		0,216	**5,49**	11,29	3900	275	5400	375	PN	PN	PN
		0,254	**6,45**	13,12	4600	320	6400	440	PNU	PNU	PNU
		0,289	**7,34**	14,76	5300	365	7300	500	PN	PN	PN
		0,375	**9,53**	-	-	-	-	-	-	-	PNU
		0,430	**10,92**	-	-	-	-	-	-	-	P
		0,476	**12,09**	-	-	-	-	-	-	-	P

0,530	**13,46**	-	-	-	-	-	-	-	P
0,226	**5,74**	13,57	3600	250	5000	345	PN	PN	PN
0,262	**6,65**	15,57	4200	290	5800	395	PU	PU	PU
0,330	**8,38**	-	-	-	-	-			P
0,415	**10,54**	-	-	-	-	-			P
0,500	**12,70**	-	-	-	-	-			P
0,610	**15,49**	-	-	-	-	-			P
0,271	**6,88**	18,23	3900	265	5300	365	PNU	PNU	PNU
0,337	**8,56**	-	-	-	-	-			P
0,380	**9,65**	-	-	-	-	-			P
0,430	**10,92**	-	-	-	-	-			P
0,500	**12,70**	-	-	-	-	-			P
0,560	**14,22**	-	-	-	-	-			P
0,630	16,00	-	-	-	-	-			P