Stainless Steel (S. St)

- Steel alloy that is highly resistance to Corrosion in a variety of environments.
- Alloying elements (Cr > 11%, Ni, Mo, Al, Cu, Si, Cb).

$Cr + O_2 \longrightarrow Cr_2O_3$ { Stable oxide film → thin adherent }

Serves to protect (insulate) the surface from further corrosion reaction (Oxidation) this process is referred as (Passivation).

Classification of Stainless Steel:

No.	Stainless St. Type	%C	%Mn	%Cr	%Ni	%Others
1	Austenitic S. St (γ. S. St.)	< o.25	< 10	11 - 24	3 - 22	Mo, Ti, Si, Nb
2	Martensitic S. St (M. S. St)	< o.2	< 1	11 – 18		
3	Ferritic S. St. (α. S. St.)	< o.2	< 1	14 – 27		
4	Precipitation Hardening S. St.	< 0.12	< 0.75	15 - 17	4 – 10.5	Si (0.4 – 0.5) Al (1.15) Cu (3.6) Cb (0.25)

Stainless Steel (S. St)

System Identify Stainless Steel:

No.	Series Designation	Groups
1	2XX	γ. S. St. (Cr – Ni – Mn) non - hardenable, non – magnetic.
2	3XX	γ. S. St. (Cr – Ni) non - hardenable, non – magnetic.
3	4XX	M. S. St. (Cr) hardenable + magnetic. α. S. St. (Cr) non - hardenable + magnetic.
4	5XX	(Cr + low c) heat resisting.

Stainless Steel (S. St)

Austenitic Stainless Steel (γ. S. St):

- Steel alloy that is highly resistance to Corrosion in a variety of environments.
- The alloying elements are (Ni + Cr) > 23%.
- They are not hardenable by H. T, they may be C. W to develop a wide range of T. S (ex. 350,000 psi).
- The Phase diagram is illustrated in fig. (28).

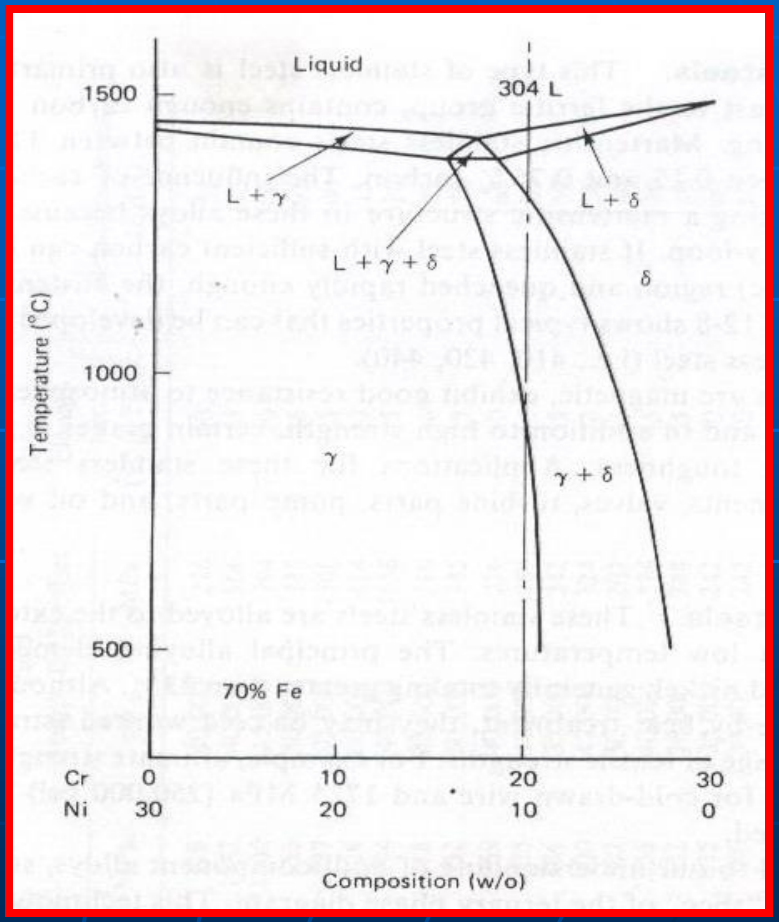

Fig. (28) Fe – Cr – Ni (Ternary Phase diagram

Stainless Steel (S. St)

Austenitic Stainless Steel (γ. S. St):

❖ Type (302, 304, 316) are the basic alloys. They are susceptible to inter-granular corrosion (along the grain boundaries, this attack can take place when (α. S. St) sensitized by heating at °T (427 – 871) for sufficient period of time.....

During this process: Cr – Carbide precipitate at the grain boundaries ⇒ depleting the Cr content (concentration in the matrix (Cr ↓ < 12%).

❖ The remedies are:

1 – Using lower %C (C < 0.02%).

2 – Using such element have stronger Carbide – forming tendency than Cr (Mo, Ti).

3 – By solution treatment (thermal treatment) called Stabilization treatment consist of:

a – Heating to a °T (1000 - 1150) °C for a period of time sufficient to dissolve Car bide.

b – Cooling rapidly (Quenching).

Stainless Steel (S. St)

Ferritic Stainless Steel (α. S. St):

- They don't respond to Heat Treatment because these alloys are Ferritic.
- Type (405, 430, 446) are the most type of (α. S. St.).
- Fig. (29) shows phase diagram which indicate that these steels fall outside (γ) loop.
- They are magnetic & can be C.W & H.W.
- The strength of (α. S. St) is 50% higher than Carbon St. if they are in the annealed condition.

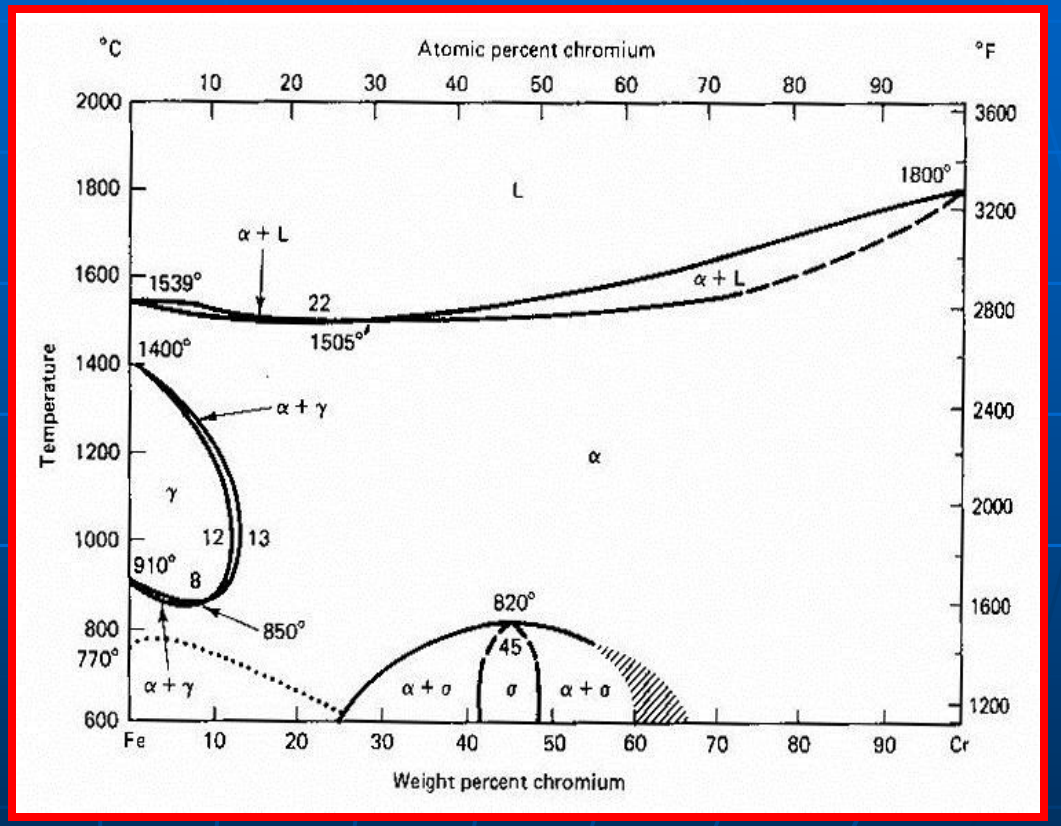

Fig. (29) Fe – Cr Phase diagram

Stainless Steel (S. St)

Ferritic Stainless Steel (α. S. St):

❖ Heat Treatment of (α. S. St.) is annealing to relieve welding and C. W stresses:

+ They annealed at °T > 850 < °T at which (γ) is formed.

+ They are not tempered since:

a – The amount of (M) formed are negligible.

b – Because of possible embrittlement.

c – Cooled slowly.

Martensitic Stainless Steel (M. S. St):

❖ Types (410, 416) are the most popular alloys, they are used for turbine blade.

❖ They are magnetic, can be C. W and are easily H. W., their corrosion resistance are < (α & γ S. St.).

Stainless Steel (S. St)

Martensitic Stainless Steel (M. S. St):

- **Heat Treatment of (M. S. St.):**
  - **+ Heating above transformation range 1850 ^{o}f.**
  - **+ Cooling in air or oil.**
  - **+ Time at ^{o}T is held to a min. to prevent:**
    - **a – The decarburization.**
    - **b – Grain growth.**
- **Tempering of these alloys should not be done in the range (750 – 950) ^{o}f because of drop in impact strength so it is usually done above 1100 ^{o}f which is the higher Temp. cause reduction in corrosion resistance.**
- **Alloys type (501, 502) have excellent resistance to oxidation and better corrosion resistance than ordinary steel.**
- **These steels hardened by oil Quenching, their mechanical properties are really intermediate between [Cr – Steel & M. S. St.], they have used for Petroleum refining equipments.**

Stainless Steel (S. St)

Precipitation hardening Stainless Steel (PH. S. St):

- They are utilized in application that required:
  - a – High strength.
  - b – Corrosion resistance < (γ. S. St.).
- They are made either → Martensitic / Semi-austenite / Austenitic } by varying Cr/Ni ratio:

Cr: Ferritic stabilizer.

Ni: Austenite (γ) stabilizer.

If Cr/Ni ratio ↓ → Austenitic Condition.

If Cr/Ni ratio ↑ → Martensitic Condition.

Stainless Steel (S. St)

Precipitation hardening Stainless Steel (PH. S. St):

- Addition of (Al, Cu, Ti, Mo) → Precipitation Hardening.
- Heat Treatment for (ex. Alloy 17 – 7 ph. S. St) as following:

Solution treated at about 1050 °C → dissolve coarse precipitates + obtain uniform (γ) solid solution.

Cooled rapidly (Quench) to RT → supersaturated solid solution.

Aging at 510 °C → fine, inter-metallic compound which strengthen the steel (σ_T =200 - 300 X 10^{-3} psi).