Marine Construction & Welding

NA21003

Autumn 2020

Cooling Rate in Welding

Cooling Rate

- Welding is an extreme thermal process
- Heat generated is dissipated as welding progresses
- Weld zone subjected to heating and cooling thermal cycle
- Cooling rate depends on– welding speed, plate thickness, temperatures etc.
- Metallurgical structure of the weld metal depends on the cooling rate

Cooling Rate

Cooling rate for relatively thick plates: $$R_{thick} = \frac{2\pi\lambda(T_c - T_0)^2}{H_{net}}$$

T_0 = initial plate temperature, (°C)
λ = thermal conductivity of base metal, (J/mm.s.°C)
R = cooling rate at the weld centre line, (°C/s)
T_c = temperature at which the cooling rate is calculated, (°C)

Cooling rate for relatively thin plates: $$R_{thin} = 2\pi\lambda\rho C_p \left(\frac{t_h}{H_{net}}\right)^2 (T_c - T_0)^3$$

t_h = thickness of the base metal, (mm)
ρ = density of base metal, (g/mm^3)
C_p = specific heat of the base metal, (J/g.^{0}C)

Cooling Rate

Plate Thickness Factor:

$$\tau = t_h \sqrt{\frac{\rho C_p (T_c - T_0)}{H_{net}}}$$

for $\tau \leq 0.75$ thin plate equation is valid,
$\tau > 0.75$ thick plate equation is valid.

Cooling Rate

Plate Thickness Factor:

$$R_{thin} = \tau^2 R_{thick}$$

Cooling Rate

A 6mm thick steel plate is to be welded at an ambient temperature of 30˚C with arc voltage of 32V and welding current 400A using single side submerged arc welding technique. The limiting cooling rate for satisfactory performance is 6˚C/s at a temperature of 550˚C. Assuming arc efficiency to be 0.7, calculate if welding can be carried out satisfactorily at the speeds of 13m/s and 11m/s. Consider λ=0.028 J/mm.s.˚C and ρC_p=0.0044 J.mm^3. ˚C

$$R_{thick} = \frac{2\pi\lambda(T_c - T_0)^2}{H_{net}} \qquad R_{thin} = 2\pi\lambda\rho C_p \left(\frac{t_h}{H_{net}}\right)^2 (T_c - T_0)^3$$

Hull Outfit & Fittings

Hull Outfit

- Closures for Hull Openings
- Deck Fittings
- Hold Sparring, Ceiling and Gratings
- Deck Coverings
- Joiner Bulkheads, Linings, Ceiling & Insulation
- Stewards Outfit
- Lifesaving systems
- Pilot Boarding

Closures for Hull Openings

Required for personnel access on weather decks and through watertight bulkheads.

(a) **Watertight Doors:** Deck House, Side Port Access, Fuelling Doors etc.

(b) **Miscellaneous type doors:** Gastight, Non-Watertight doors etc.

(c) **Windows, Air ports**

(d) **Access hatches, manholes**

(e) **Cargo Hatch covers:** Single, mechanical, rolling, folding types

(f) **Ventilation system terminals**

Deck Fittings

These include a large assortment of items attached to the hull on the weather deck to perform certain ship functions.

(a) **Bulwark, Rails and Stanchions**

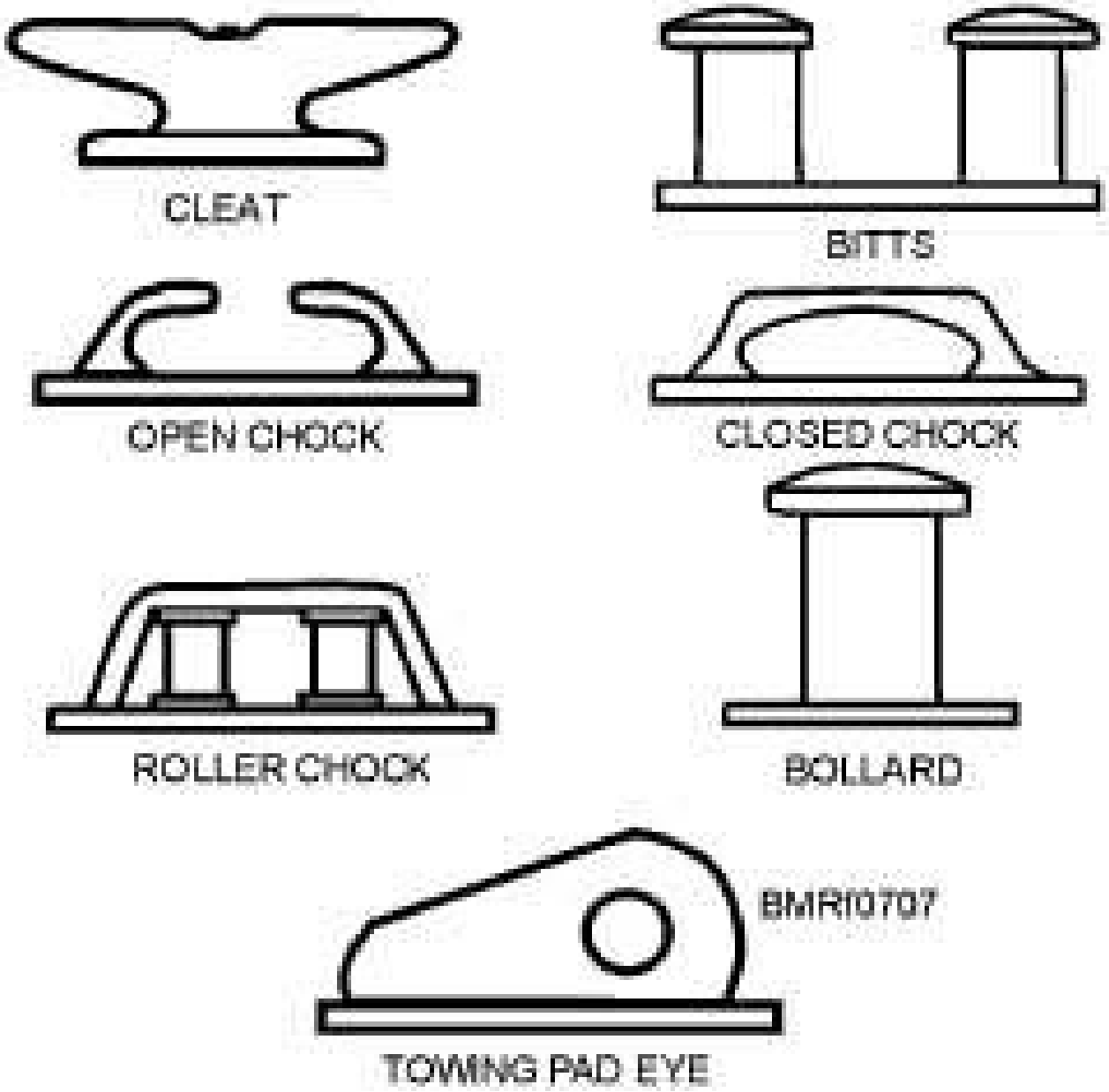
(b) **Ladders and Stairs**

(c) **Mooring Fittings:** Mooring bitts and rings etc.

(d) **Stores handling gear:** Davits, cranes etc.

(e) **Deck Stowage:** Lashing cables, locking systems etc.

(f) **Miscellaneous Rigging Fittings**


CLEAT
BITTS
OPEN CHOCK
CLOSED CHOCK
ROLLER CHOCK
BOLLARD
BMR10707
TOWING PAD EYE

Lifesaving Systems

These include a large assortment of items attached to the hull on the weather deck to perform certain ship functions.

(a) Lifeboats

(b) Life Rafts

(c) Rescue Boats

(d) Davits

(e) Winches