HARD ROCK MINE VENTILATION

REFRIGERATION AND REFRIGERATION STRATEGIES

BY

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HARD ROCK MINE VENTILATION

MINE REFRIGERATION REQUIRED = MINE HEAT LOAD – COOLING CAPACITY OF THE AIR

MINE HEAT LOAD

- ❑Auto-compression
- ❑Heat from rock surfaces
- ❑Equipment – diesel and electric
- ❑Fissure water and broken rock
- ❑Miscellaneous

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COOLING CAPACITY OF THE AIR = COOLING CAPACITY OF AIR AT DESIGN CONDITION – COOLING CAPACITY OF THE AIR ON SURFACE

DESIGN CONDITIONS

- Wet bulb 32.5°C – Stop work
- Wet bulb 30.5°C – Modified conditions
- Wet bulb 28.0°C – Optimum productivity

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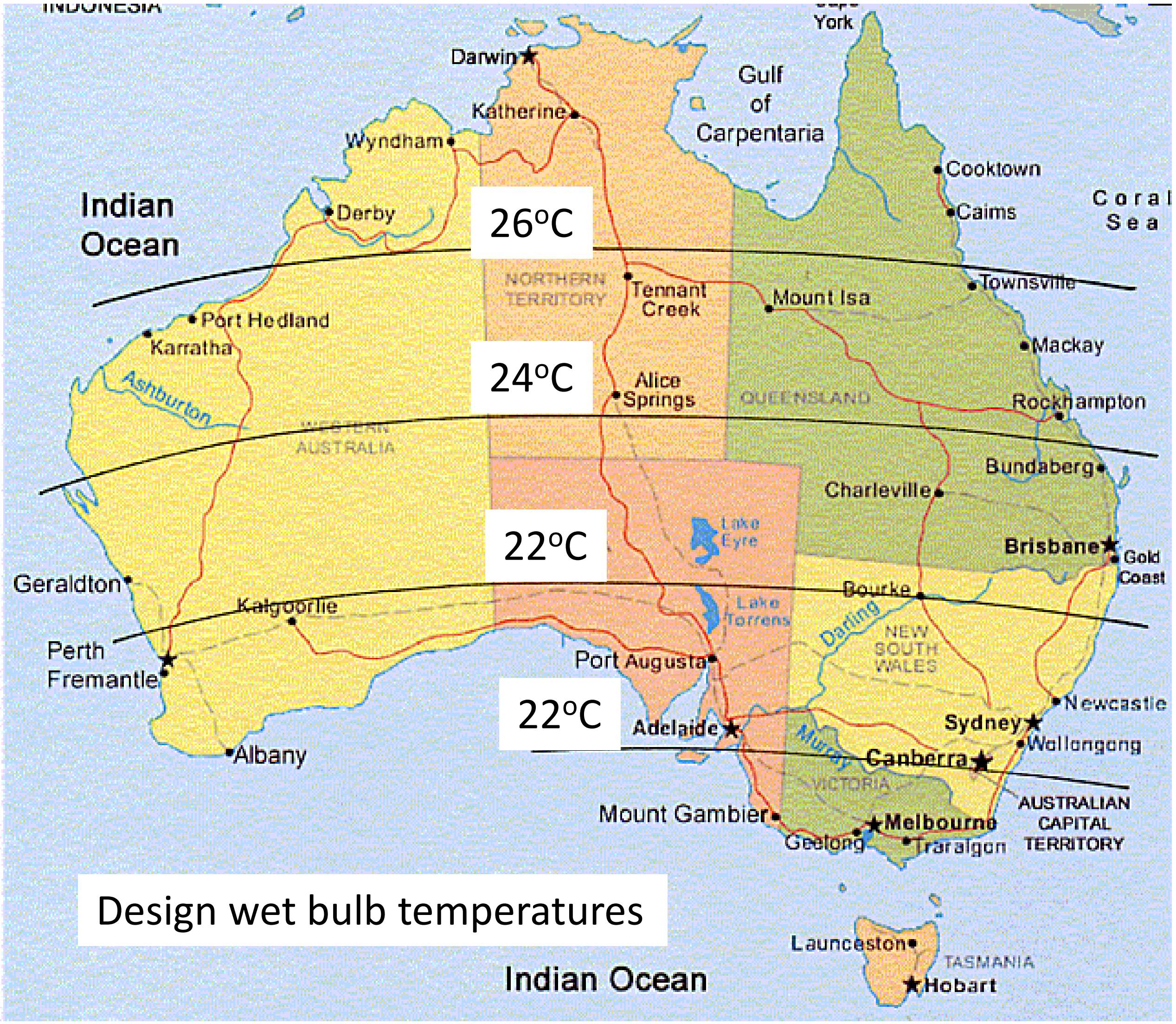

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CRITICAL DEPTH

- The depth at which the residual cooling power of the air is zero.
- It is mainly a function of surface temperature and depth of workings (auto-compression).
- Heat flow from rock is not normally important at about 10% of the total heat load.
- Equipment heat is usually constant and depends on production rate except for a decline haulage.
- Hot fissure water may be dominant.

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TYPICAL CRITICAL DEPTHS

- Argyle/Ranger 2 – 700 to 800 m
- Mount Isa/Telfer/Granites – 1000 to 1100 m
- Leinster/Wiluna – 1300 to 1400 m
- Kalgoorlie/CSA – 1500 to 1600 m
- Olympic Dam/ Broken Hill – 1800 to 2000 m

This is not necessarily the depth at which refrigeration is required and illustrates the effect of surface conditions and depth

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ORDER OF MAGNITUDE ESTIMATES

DEPTH – 0.5^{o}C WB increase per 100 m

DECLINE HAULAGE – 450 kW per Mtpa.km (i.e. 5400 kW from1.5 Mtpa and 1000 m at 1:8)

HEAT/WB CONVERSION – 4.5 kW/m^{3}/s per ^{o}C

EQUIPMENT WB's – No diesels 1.0 to 1.5^{o}C

- diesels 3.0 to 4.5^{o}C

(thermal flywheel effect and design conditions)

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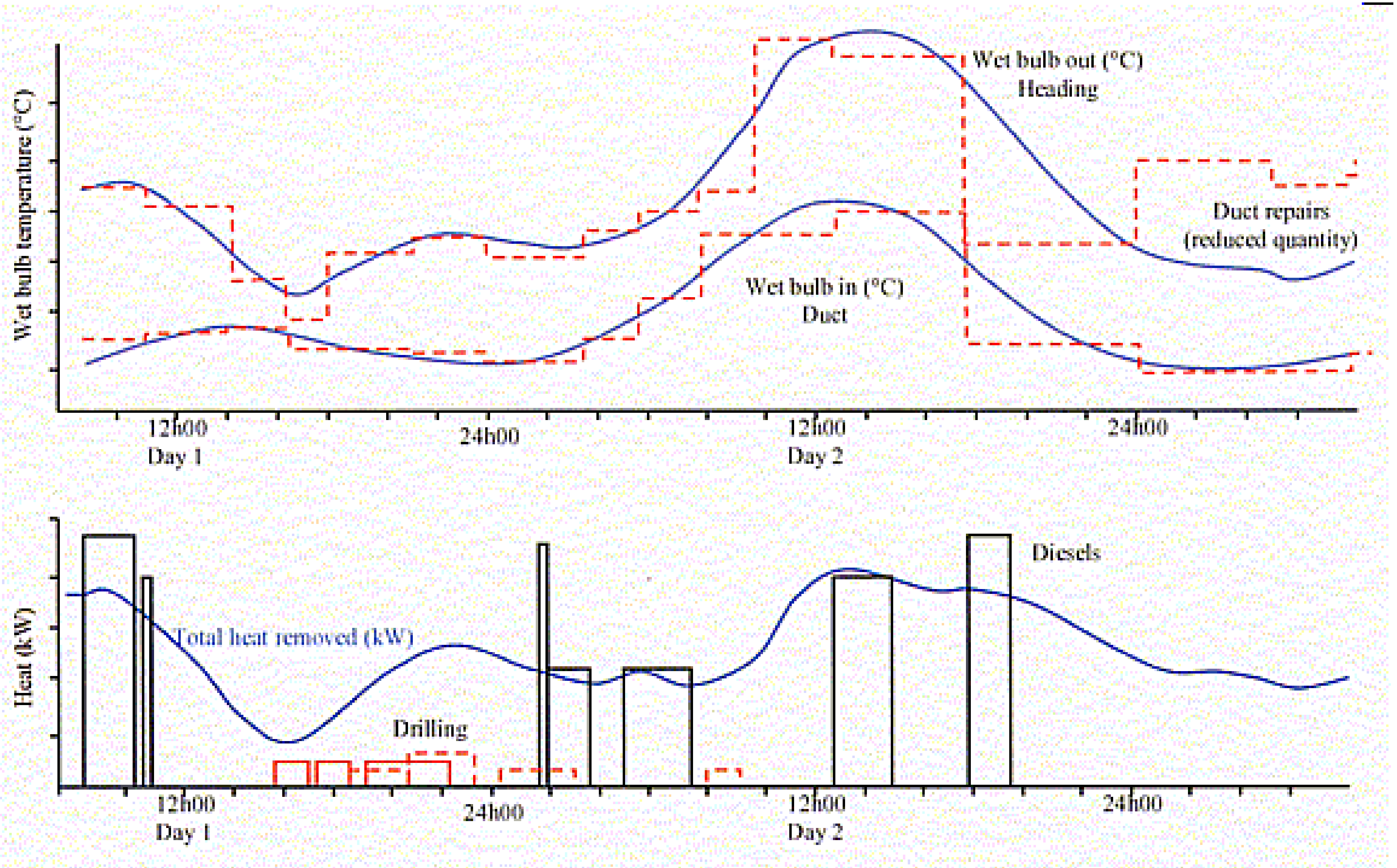

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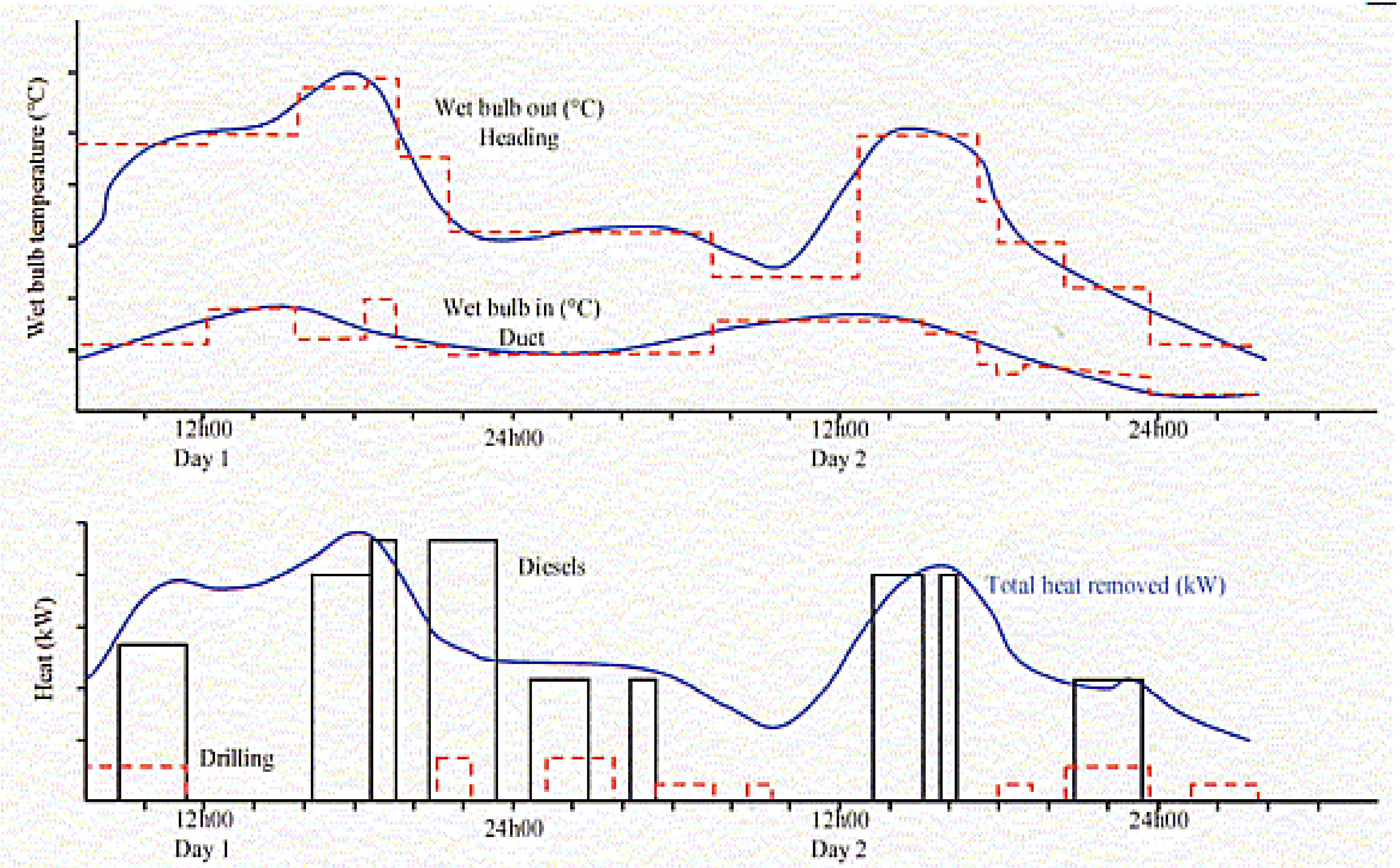

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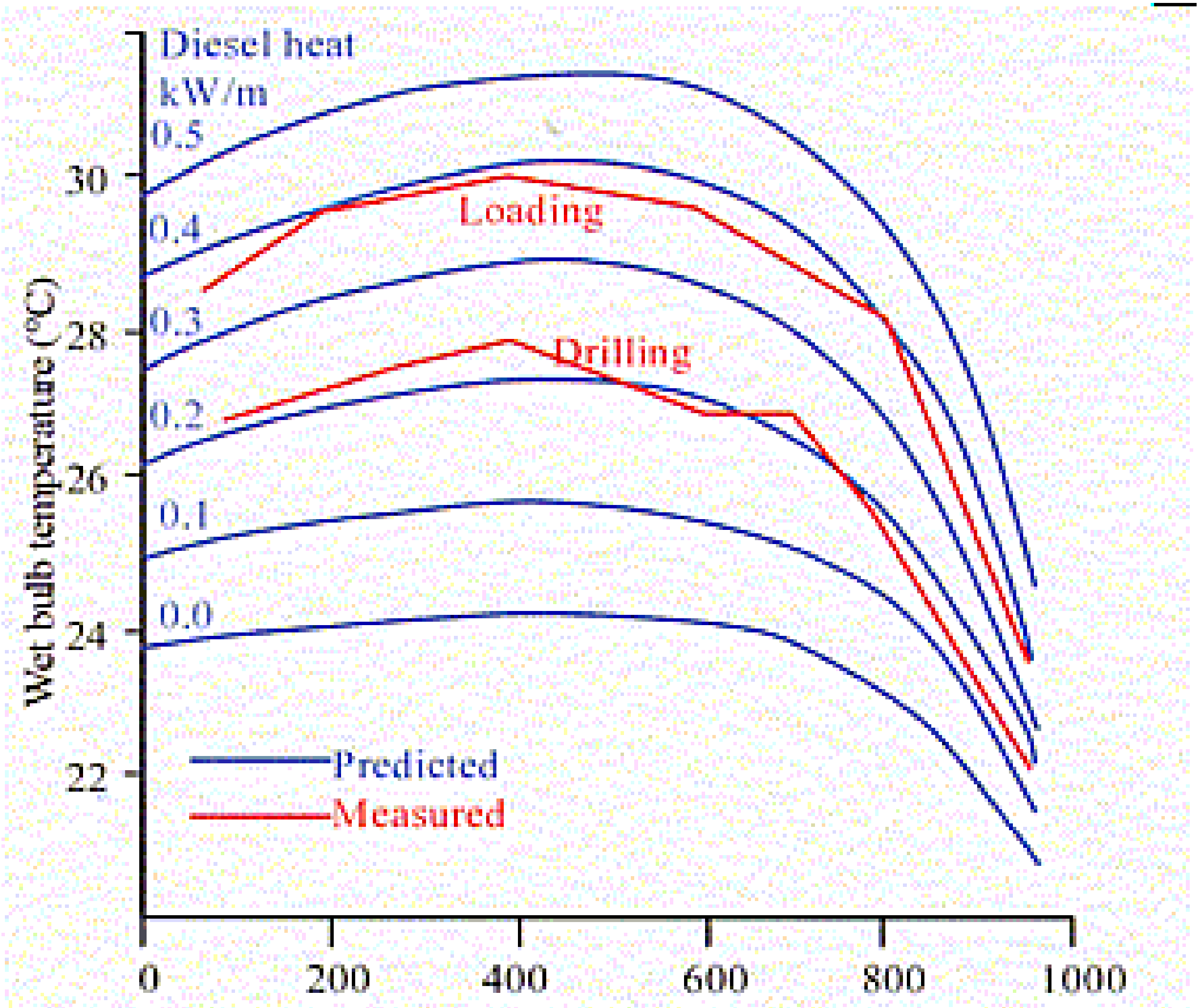

Distance along drive (m)

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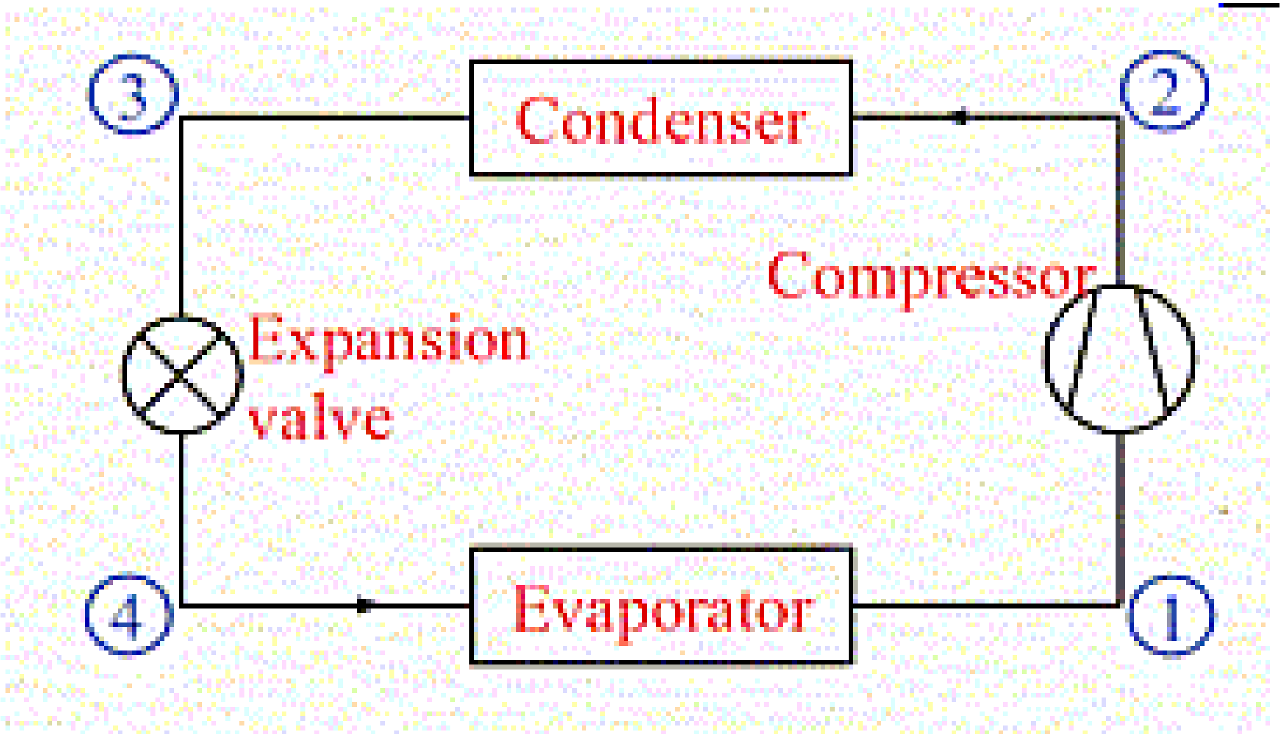
Vapour compression



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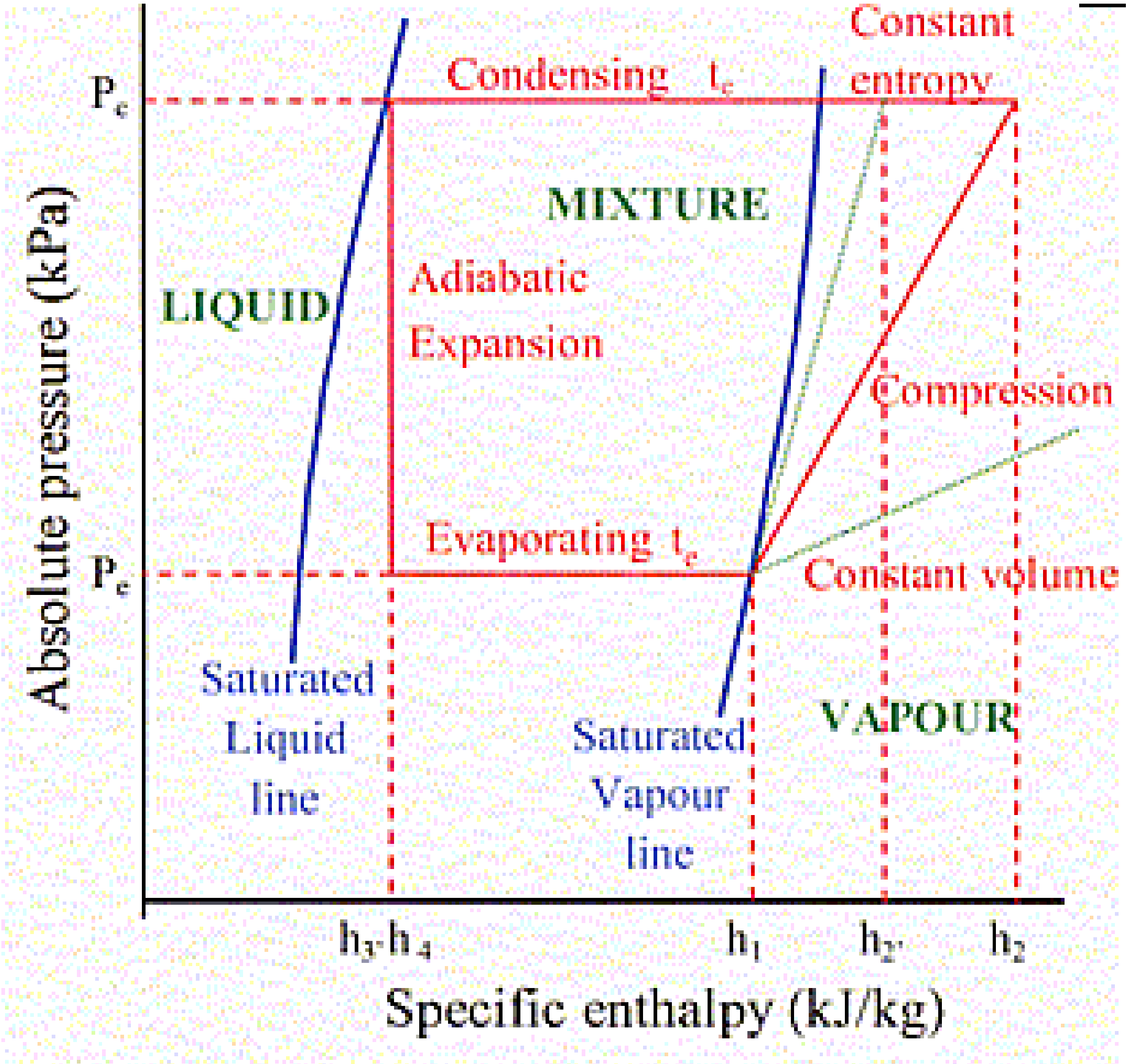

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INCREASED CONDENSING TEMPERATURE RESULTS IN INCREASED INPUT POWER

Heat rejection (condensing) on surface depends on the ambient wet bulb temperature and U/G depends on the mine exhaust wet bulb.

Surface wet bulbs are always lower than U/G exhaust wet bulb temperatures and surface plants result in significant power savings.

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WET OR DRY CONDENSING

Wet bulb temperature is always equal to or less than the dry bulb temperature therefore **wet condensing has lower power requirement.**

Wet condensing does however require water to offset evaporation and a mine in the Tanami, required about **9.0 Ml per MWR per summer.**

When operating dry, the shortfall in cooling was 12.5% and power was 40% greater.

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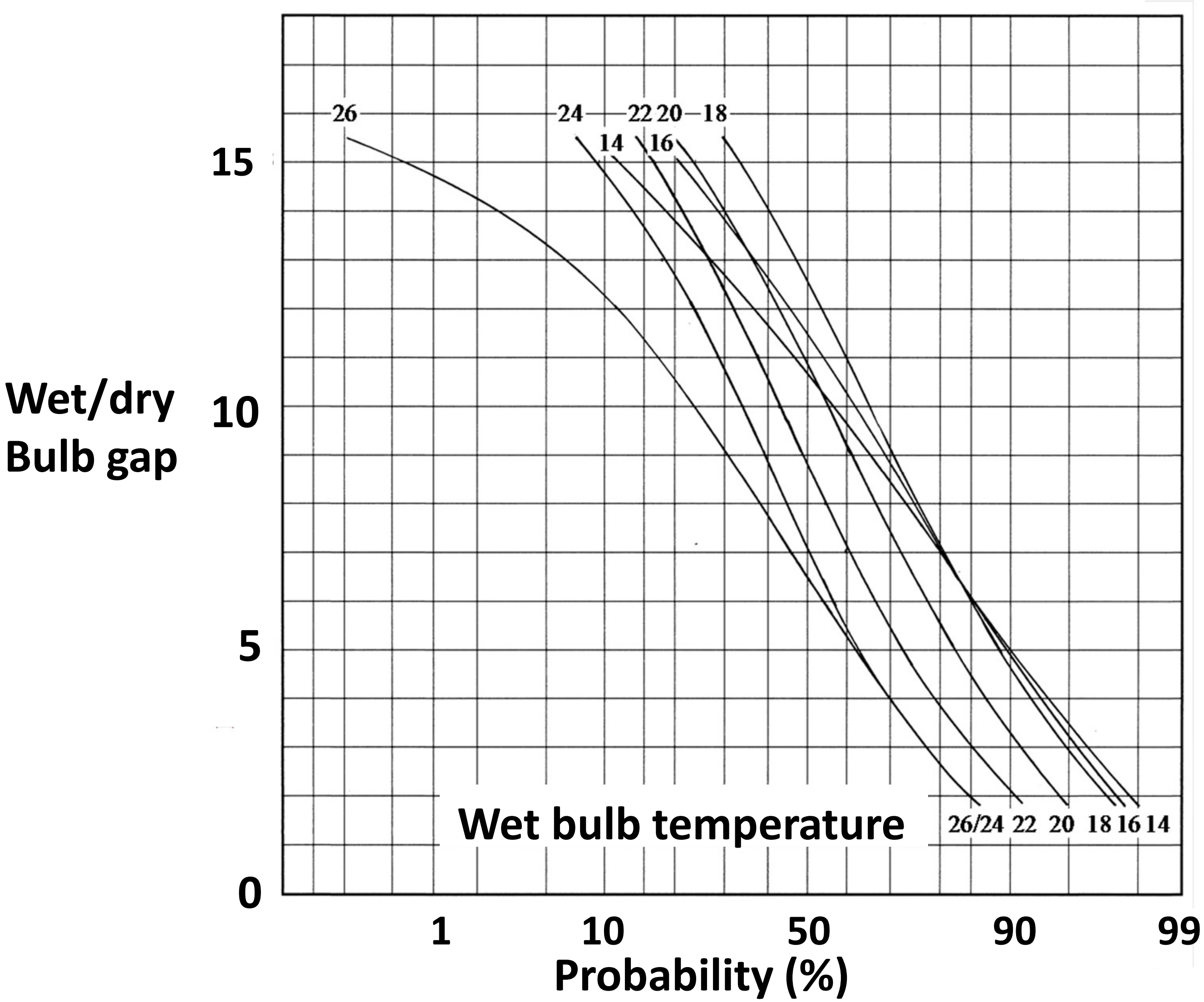

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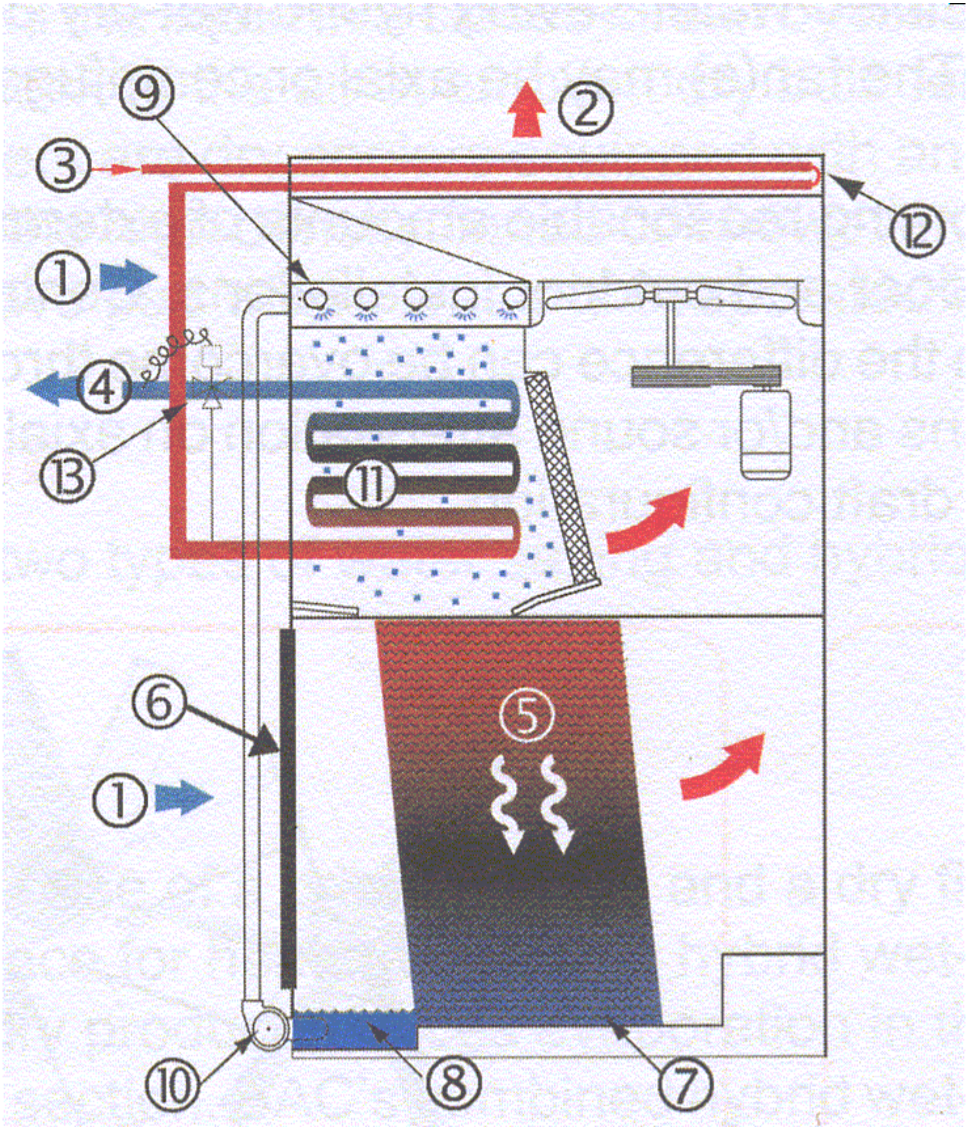

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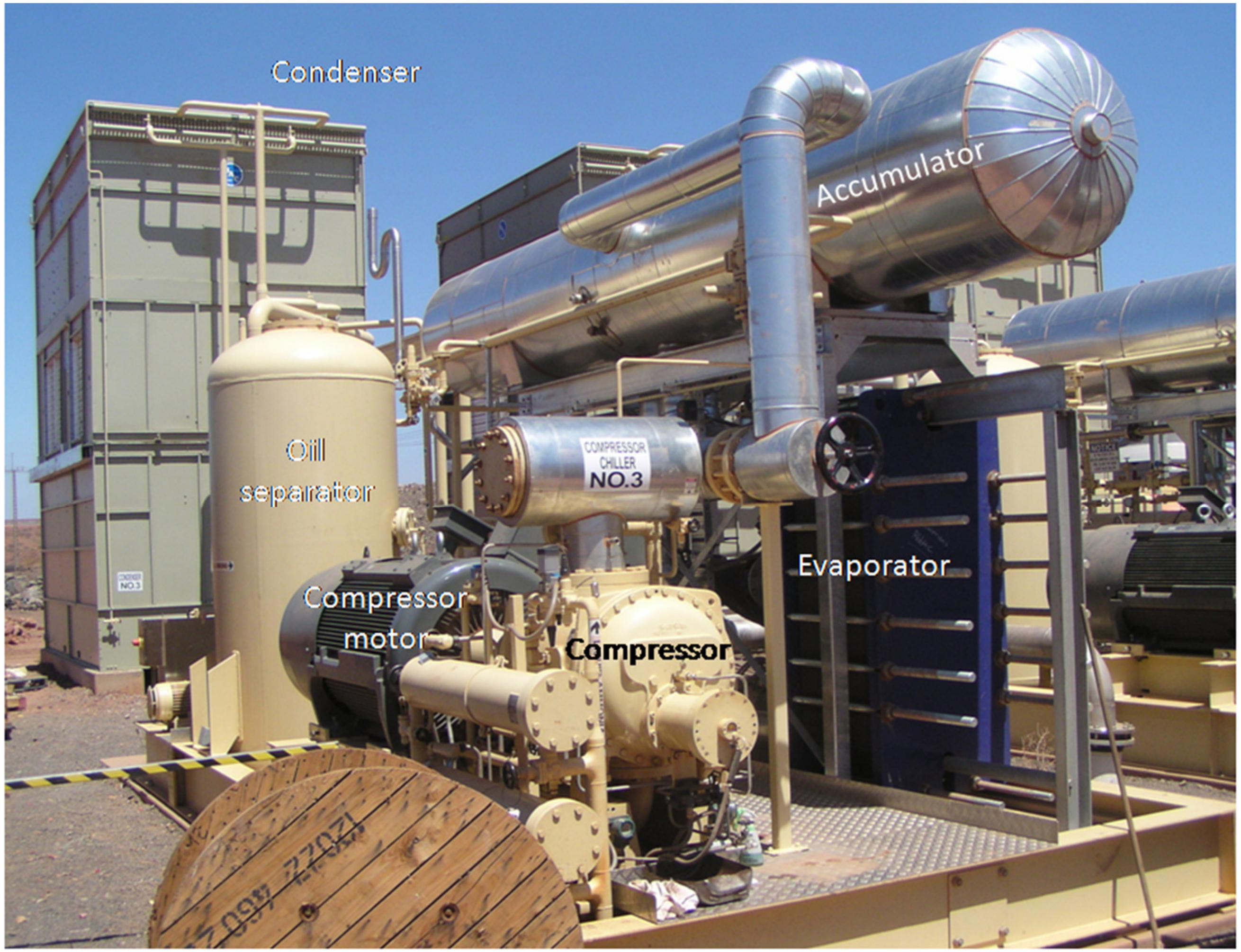

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LOWER EVAPORATING TEMPERATURES REDUCE THE CAPACITY OF THE COMPRESSOR BUT INCREASE THE AMOUNT OF COOLING THAT CAN BE TRANSFERED BY THE SECONDARY COOLANT (USUALLY WATER).

Heat transfer = m c_p Δ_t

Limited by freezing point of water.

If return water is 28 ^oC and supply is 1 ^oC, each kg (litre)/s of water transfers 113 kW.

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ADVANTAGE OF USING ICE – INCREASED CAPACITY OF SECONDARY COOLANT

- Latent heat of fusion of ice is 334 kJ/kg i.e. if ice is used as a secondary coolant, the mass of water/ice is only 25% of water alone.
- Relevant to deep mines with large refrigeration requirements i.e. ERPM in South Africa.
- Plant produces 6000 t of ice per day which provides 31 MWR (Hemp, 1988).

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SOME MINING AREAS SUCH AS CANADA HAVE COLD WINTERS AND, WHERE DEEP MINES REQUIRE COOLING IN THE SUMMER, ICE STORAGE SYSTEMS ARE POSSIBLE.

This is not a new concept in that the forming of ice was used as mine air heating process. If cold air is passed through water sprays, the water will be frozen by the **coolth** taken from the air which as a consequence is **heated**.

Sometimes known as ice stopes i.e. Creighton

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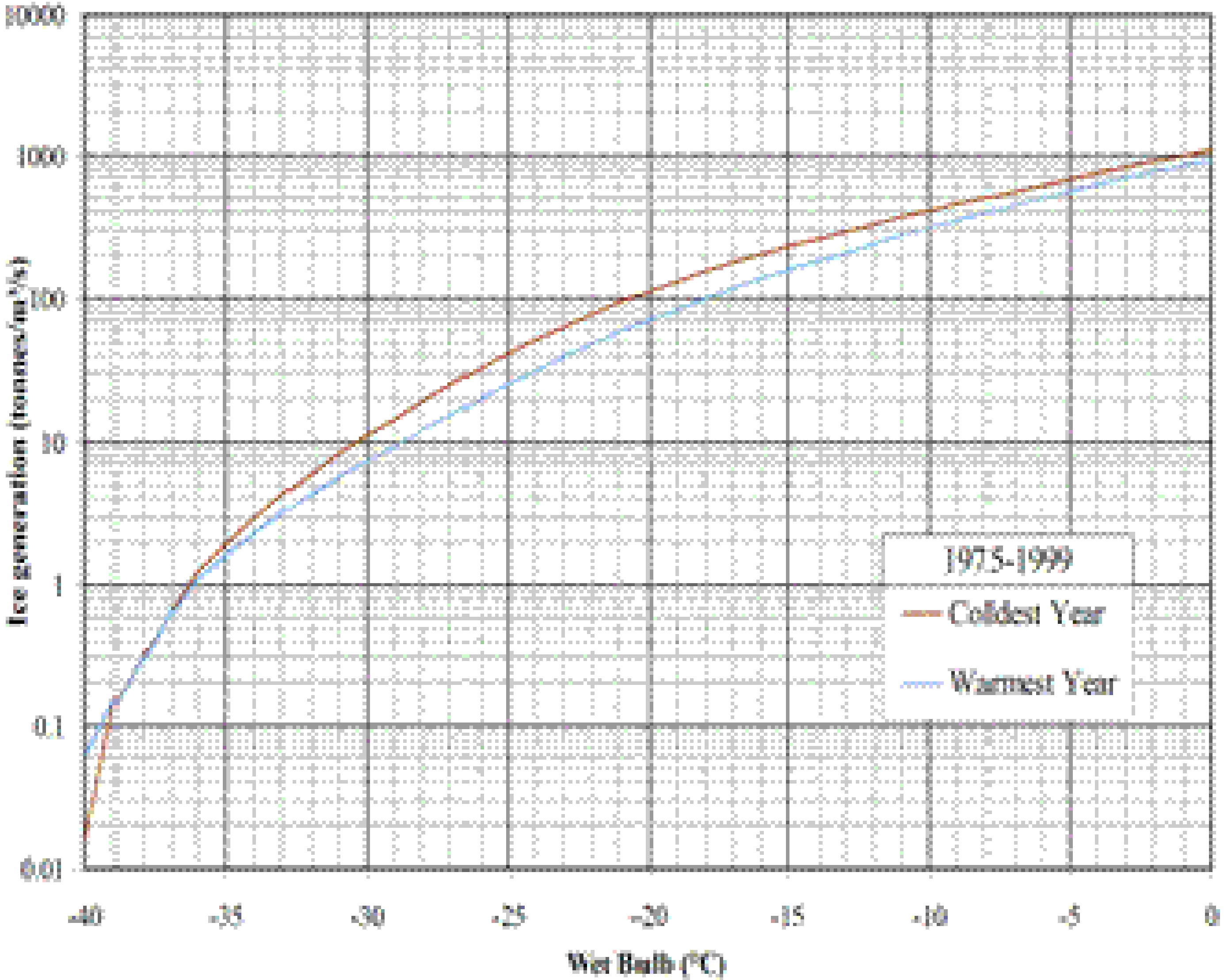

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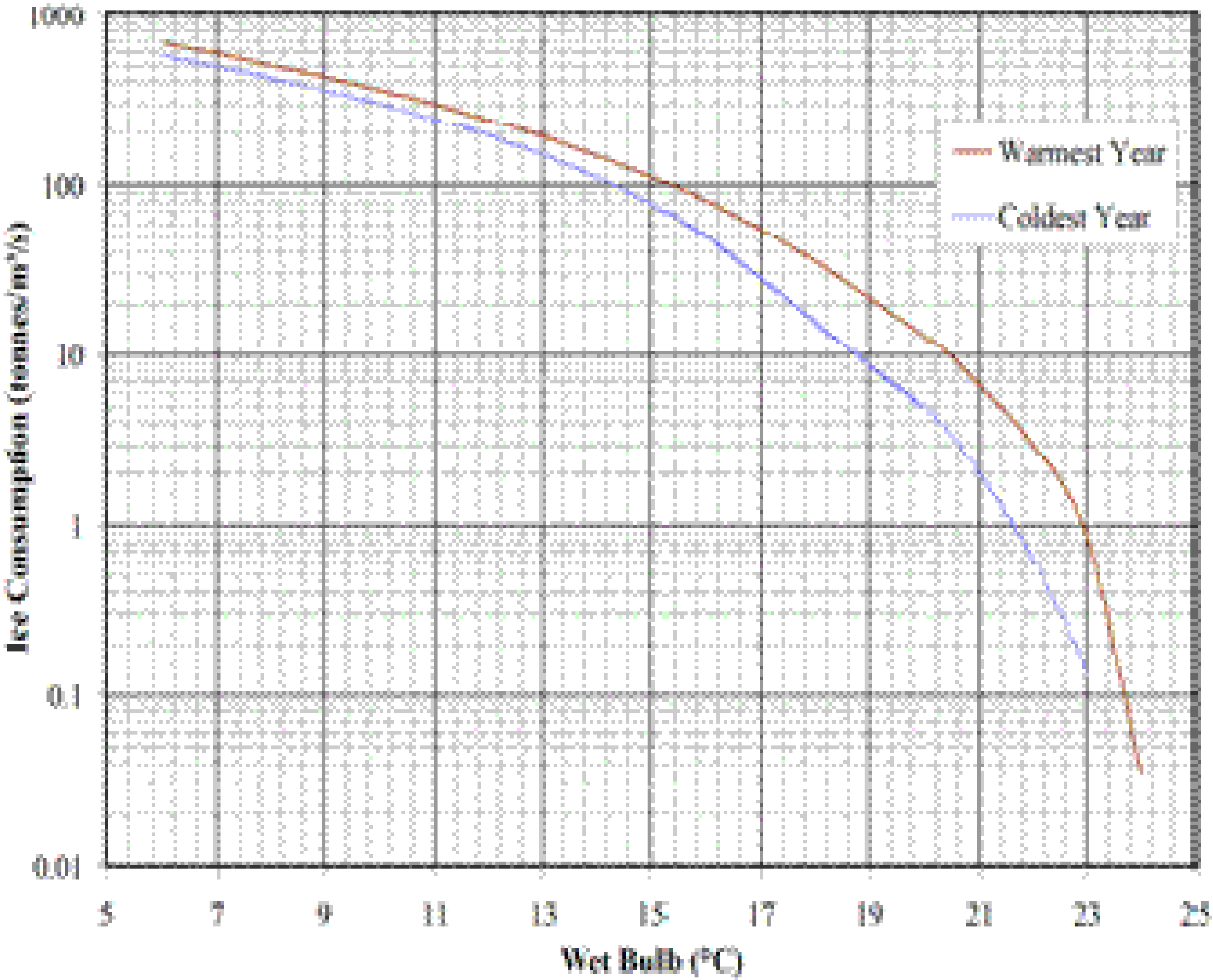

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1.0 m^3/s of air over a winter will produce about 650 t of ice by heating air to -4 °C. Mine air heating cost saving is about \$ 4000/m^3/s.

Depending on the design intake wet bulb temperature, the cooling of 1.0 m^3/s requires between 200 t and 450 t of ice.

Ice storage costs are site specific and, in the glacial till (clay) at Kidd Creek, the cost was approximately \$ 75/t or equivalent to the capital cost of mechanical refrigeration.

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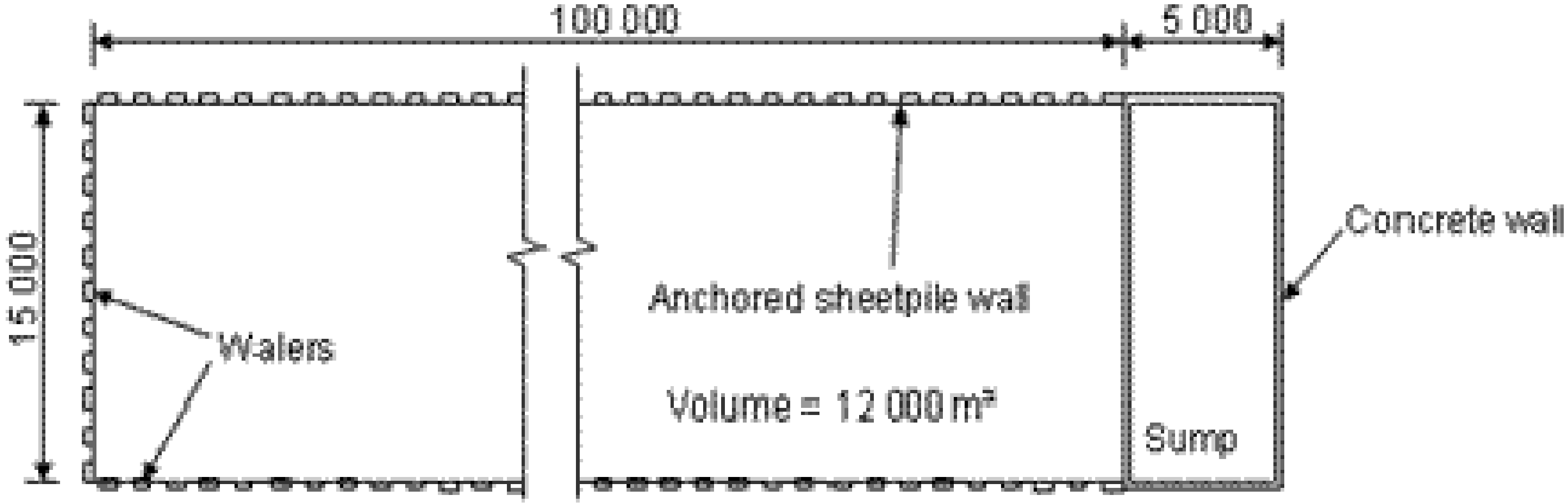

Plan view

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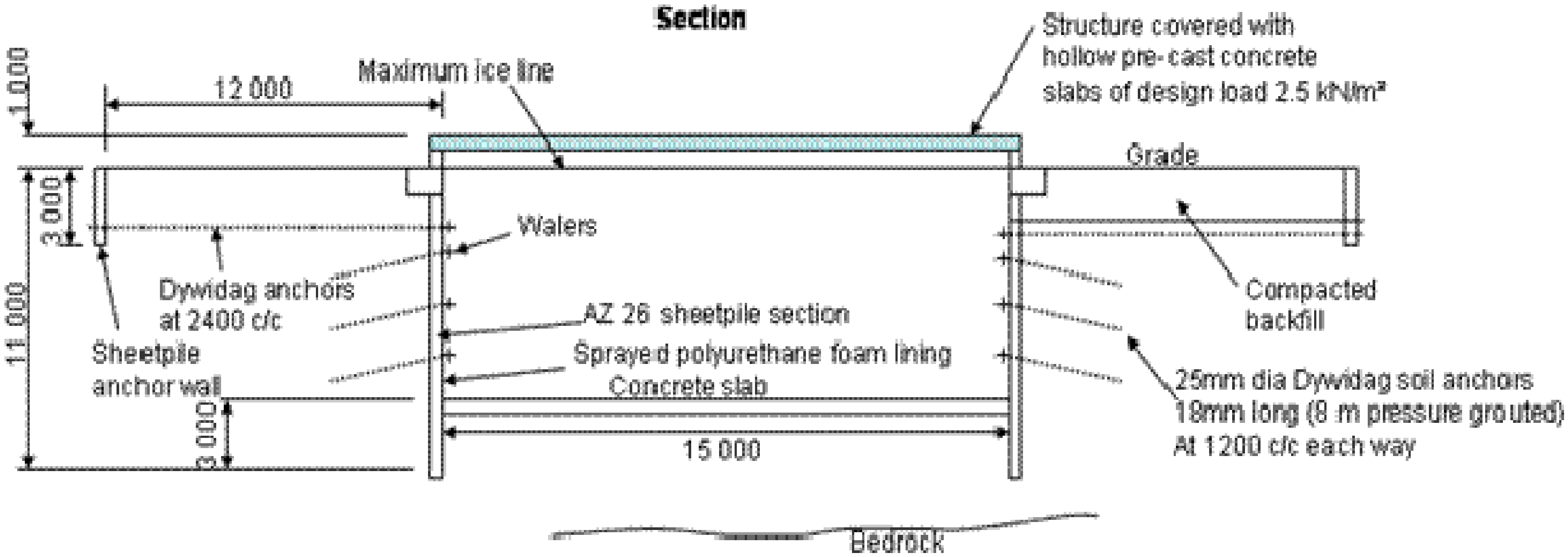

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- **At a similar mine (climate and location), an open pit had a potential ice storage volume of about 500 000 t with an equivalent cooling capacity of just over 30 MWR. The cost was about two thirds that of a conventional plant.**
- **The use of ice for both cooling and heating is still limited to old stopes or caved areas.**
- **Kidd Creek avoided installing a further 6 MWR compressor set by enlarging the cold stope ice storage volume underground.**

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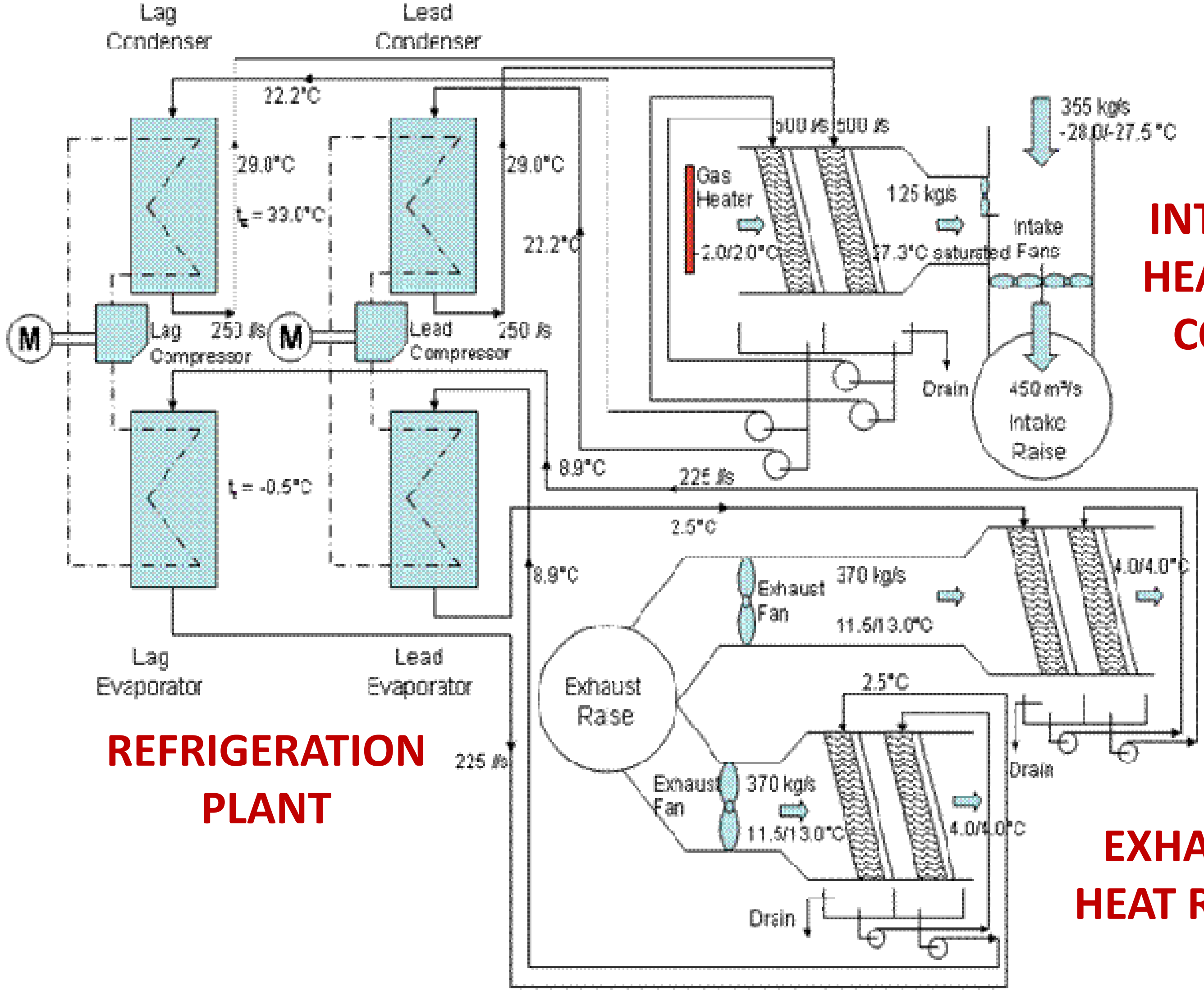

INTAKE AIR HEATING OR COOLING

REFRIGERATION PLANT

EXHAUST AIR HEAT RECOVERY

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HEAT RECOVERY SYSTEM USING REFRIGERTION PLANT

Additional capital cost of mine refrigeration plant is about $ 2.5 million.

Annual saving in heating costs less operating power and maintenance of the heat recovery system is about $ 0.8 million.