RETA Book 1 Chapter 1 – Fundamental Items

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RETA Certification Levels

CARO – Certified Assistant Refrigeration Operator

- CARO is an entry-level credential that is designed to demonstrate that an operator has sufficient knowledge to work under supervision in industrial refrigeration. There is no minimum experience requirement for CARO. The exam assesses mastery of concepts and principles in RETA’s Industrial Refrigeration I and the ammonia safety chapter in Industrial Refrigeration IV (chapter 7).
- CARO includes 110 questions and allows three hours for completion.

RETA Certification Levels

CIRO – Certified Industrial Refrigeration Operator

- CIRO requires documentation of at least two years of experience as a industrial refrigeration operator. It assesses more advanced concepts, principles and applications required to supervise industrial refrigeration operations. CIRO measures mastery of applied refrigeration system operations and troubleshooting based on principles and knowledge addressed in RETA books: Industrial Refrigeration (IR) I · IR II (systems) IR IV (plant operation and safety) Basic Electricity (BE) I · Basic Electricity (BE) II (ladder diagrams)
- The CIRO exam consists of 135 questions and allows three hours for completion.

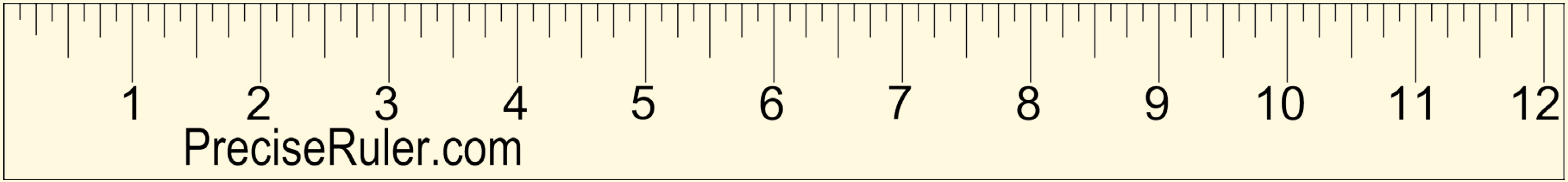
CARO Exam Content

Refrigeration Fundamentals	10 Questions
Refrigeration Cycle	9 Questions
Properties of Refrigerants and Refrigerant Tables	10 Questions
Types of Refrigerant Compressors	7 Questions
Operation and maintenance of compressors	15 Questions
Lubrication	10 Questions
Evaporators and Cooling Units	9 Questions
Condensers and High Pressure Receivers	10 Questions
Purging	4 Questions
Safety, Hazards, and Prevention	16 Questions

Objectives

1. Explain the difference between sensible heat and latent heat
2. Explain the relationship between force and pressure
3. Explain the difference between heat energy and temperature
4. Describe the condition of refrigerant liquids and vapors in terms of heat, temperature, and pressure
5. Discuss the duties of a refrigeration operator / technician
6. Use sensible heat and latent heat formulas to calculate refrigeration loads

Units of Measurement - Length



Units of Measurement - Length

1 ft = 12 in
1 mile = 5,280 ft
1 yard = 3 ft

1000 mm = 1 m
100 cm = 1 m
1,000 m = 1 km

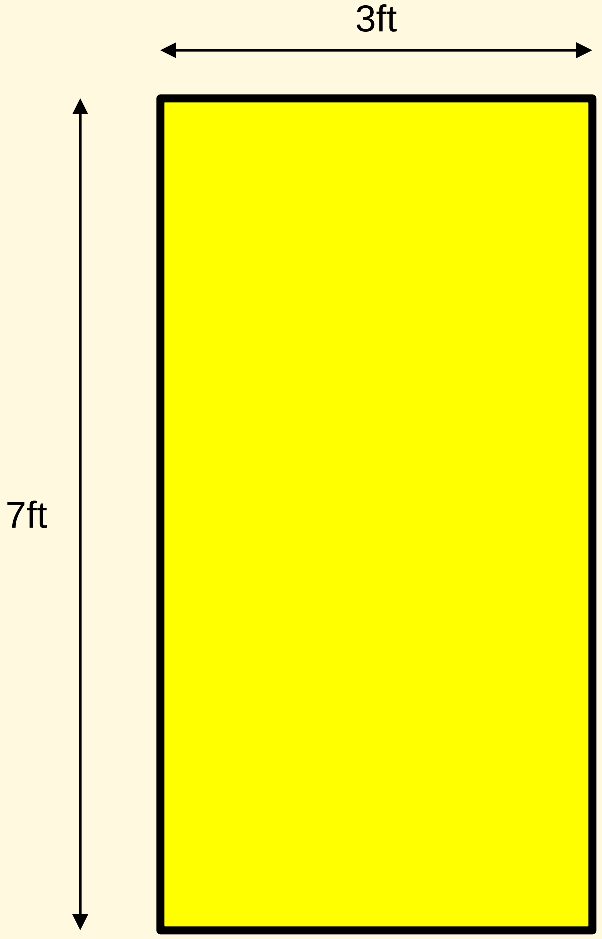
1 mile = 1.60934 km
1 m = 3.28084 ft
1 in = 2.54 cm

Units of Measurement - Length

How many feet are in 5 km?

$$L(ft) = 5km \times \frac{mile}{1.60934km} \times \frac{5{,}280ft}{mile} = 16{,}404ft$$

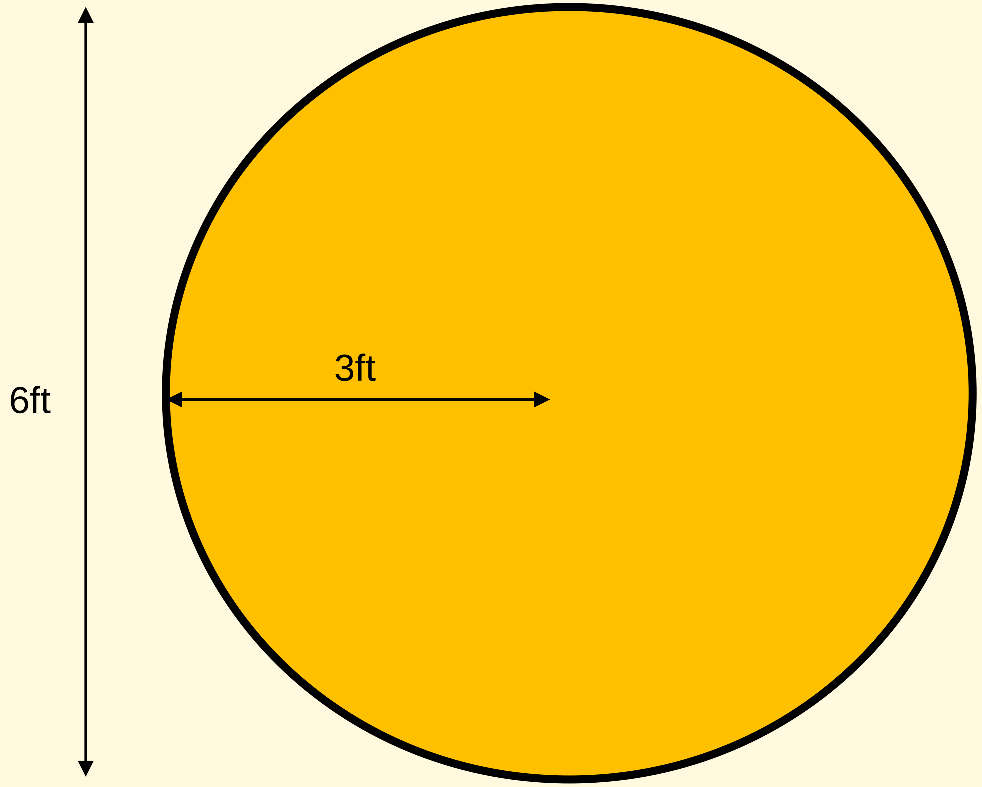
Units of Measurement - Area



1	2	3
4	5	6
7	8	9
10	11	12
13	14	15
16	17	18
19	20	21

$$A = L \times W = 7ft \times 3ft = 21ft^2$$

Units of Measurement - Area



$$A = \pi \times r^2$$

$$D = 2 \times r$$

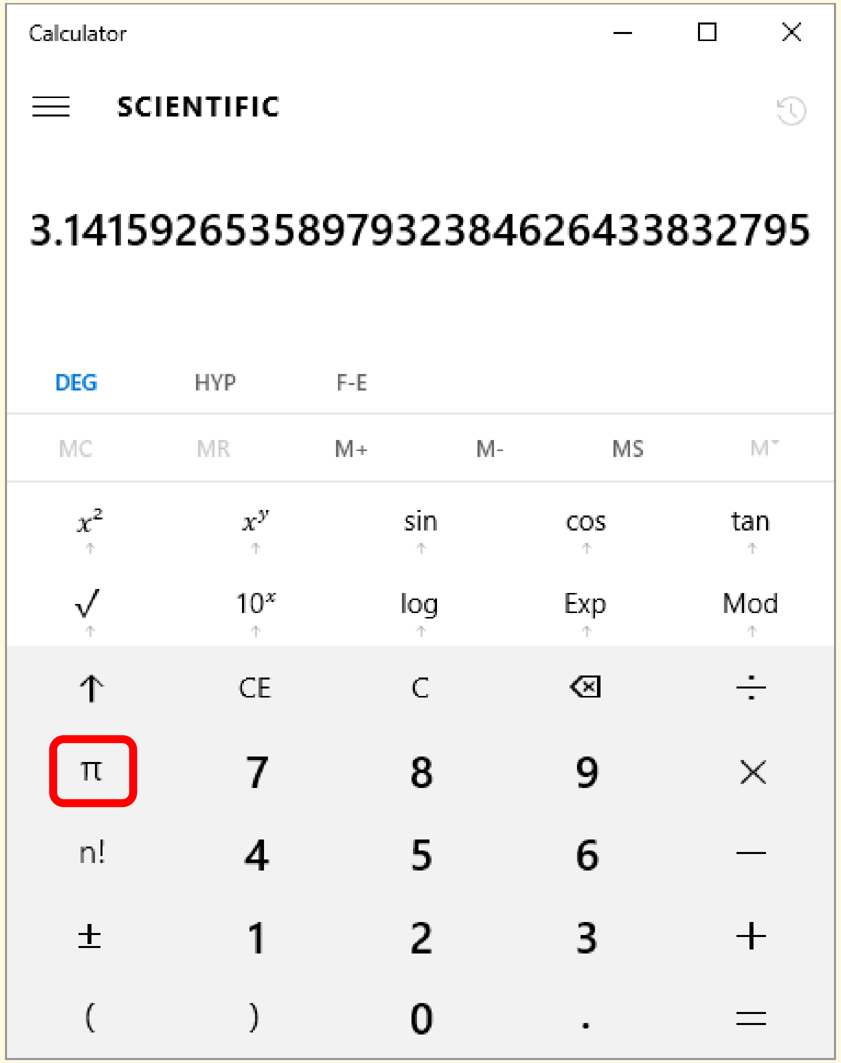
$$A = \pi \times \frac{D^2}{4}$$

$$A = \pi \times (3ft)^2$$

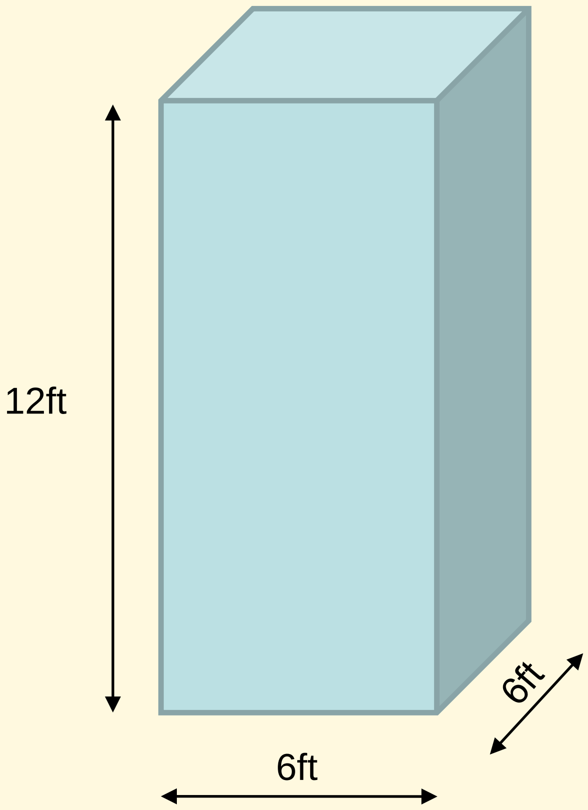
$$A = 28.27ft^2$$

Units of Measurement - Area

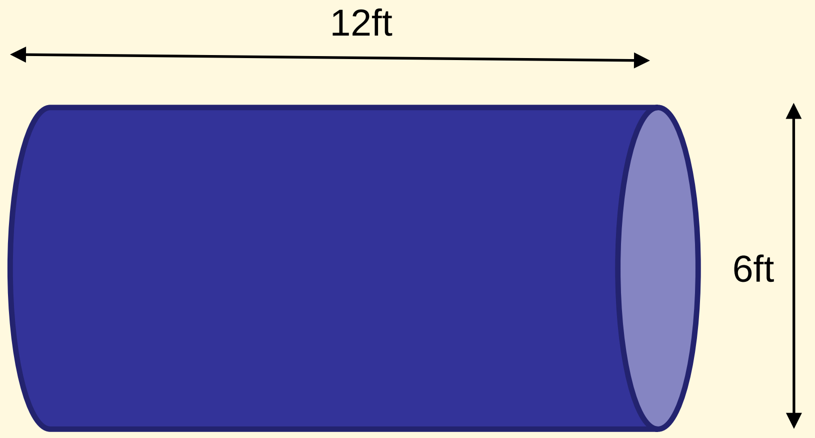
π



Units of Measurement - Volume



$$V = L \times W \times H$$
$$V = 12ft \times 6ft \times 6ft$$
$$V = 432ft^3$$



$$V = A \times L$$
$$V = \pi \times r^2 \times L$$
$$V = \pi \times (3ft)^2 \times (12ft)$$
$$V = 339.3ft^3$$

Units of Measurement - Rate

$$Rate = \frac{measurement}{time}$$

$$MPH = \frac{miles}{hr}$$

$$GPM = \frac{gallons}{min}$$

$$FPM = \frac{ft}{min}$$

$$CFM = \frac{ft^3}{min}$$

$$Tr = \frac{288{,}000Btu}{24hr}$$

Units of Measurement – Weight and Mass

$$W = m \times g$$

$$W = 200\ lb_m \times 32.2\ ft/s^2 \times \frac{s^2 \cdot lb_f}{32.2 lb_m \cdot ft}$$

$$W = 200 lb_f$$

Units of Measurement – Weight and Mass

A 200lb_m person weighs:

- 200lb_f on earth
- 33lb_f on moon
- 505.6lb_f on Jupiter
- 5,580 lb_f on sun

Pressure

$$P = \frac{F}{A}$$

Pressure

- If a 200 lb man stands on a 2ft x 2ft square platform, what pressure is exerted on the platform?

$$P = \frac{F}{A}$$

$$A = L \times W$$

$$A = 2ft \times 2ft = 4ft^2$$

$$P = \frac{200lb}{4ft^2} = 50\frac{lb}{ft^2} \times \frac{1ft^2}{144in^2} = 0.3472psi$$

Pressure

$$P = \frac{F}{A}$$

Pressure

- **Gauge** pressure (P_g) is the pressure measured relative to ambient pressure
- **Absolute** pressure (P_a) is the measured gauge pressure added to ambient pressure

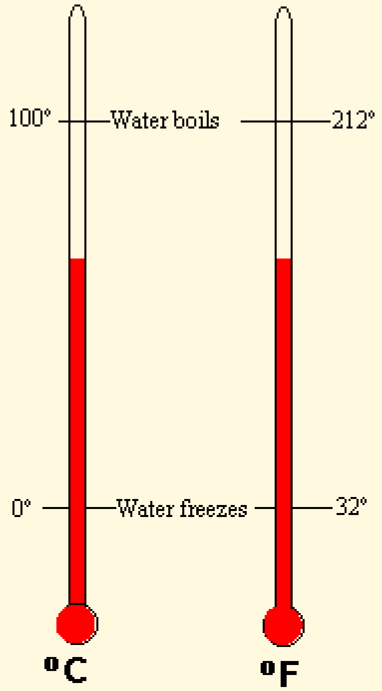
$$P_a = P_g + 14.7$$

Temperature

- Temperature is a measurement of the **intensity** of heat

$$°F = \left(\frac{9 \times °C}{5}\right) + 32$$

$$°C = \frac{(°F - 32) \times 5}{9}$$



Temperature

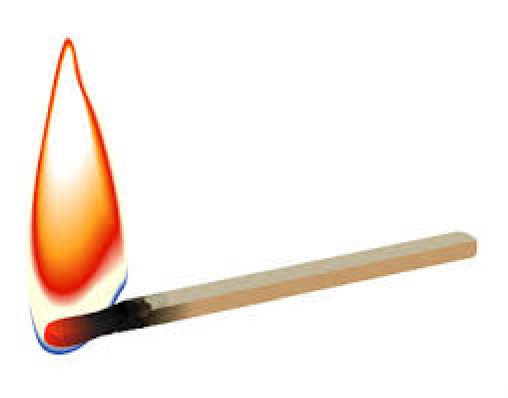
- Convert 77°F to °C

$$°C = \frac{(°F - 32) \times 5}{9}$$

$$°C = \frac{(77 - 32) \times 5}{9} = 25°C$$

Heat

- In science, **heat** is synonymous with **energy** and **work**
- BTU = British Thermal Unit
- 1 BTU is the amount of heat required to change the temperature of 1lb of water 1°F



Heat Transfer Equation - Sensible

$$Q = M \times C \times \Delta T$$

- Where:
  - Q = heat required (BTU)
  - M = mass of substance (lb)
  - C = specific heat capacity (BTU/lb-^{o}F)
  - $\Delta T = T_2 - T_1$ = Difference between the starting temperature and the ending temperature (^{o}F)

Example 1

- Determine the BTUs required to warm 2 lb of water from 40ºF to 70ºF.

$$Q = M \times C \times \Delta T$$

$$Q = 2lb \times 1\frac{BTU}{lb \cdot ºF} \times (70ºF - 40ºF)$$

$$\underline{\boldsymbol{Q = 60\ BTU}}$$

Example 2

- Determine the BTUs required to warm 2 lb of iron from 40ºF to 70ºF.

$$Q = M \times C \times \Delta T$$

$$Q = 2lb \times 0.118 \frac{BTU}{lb \cdot ºF} \times (70ºF - 40ºF)$$

$$\underline{\boldsymbol{Q = 7.08\ BTU}}$$

Heat Transfer Equation - Latent

$$Q = M \times h_L$$

- Where:
  - Q = heat required (BTU)
  - M = mass of substance (lb)
  - h_L = specific enthalpy (BTU/lb)

Example 3

- Determine the BTUs required to boil 2 lb of 212ºF water into steam.

$$Q = M \times h_L$$

$$Q = 2lb \times 970\frac{BTU}{lb}$$

$$\underline{\boldsymbol{Q = 1,940\ BTU}}$$

Heat Transfer Equation - Combined

$$Q_{Total} = Q_{Sensible} + Q_{Latent}$$

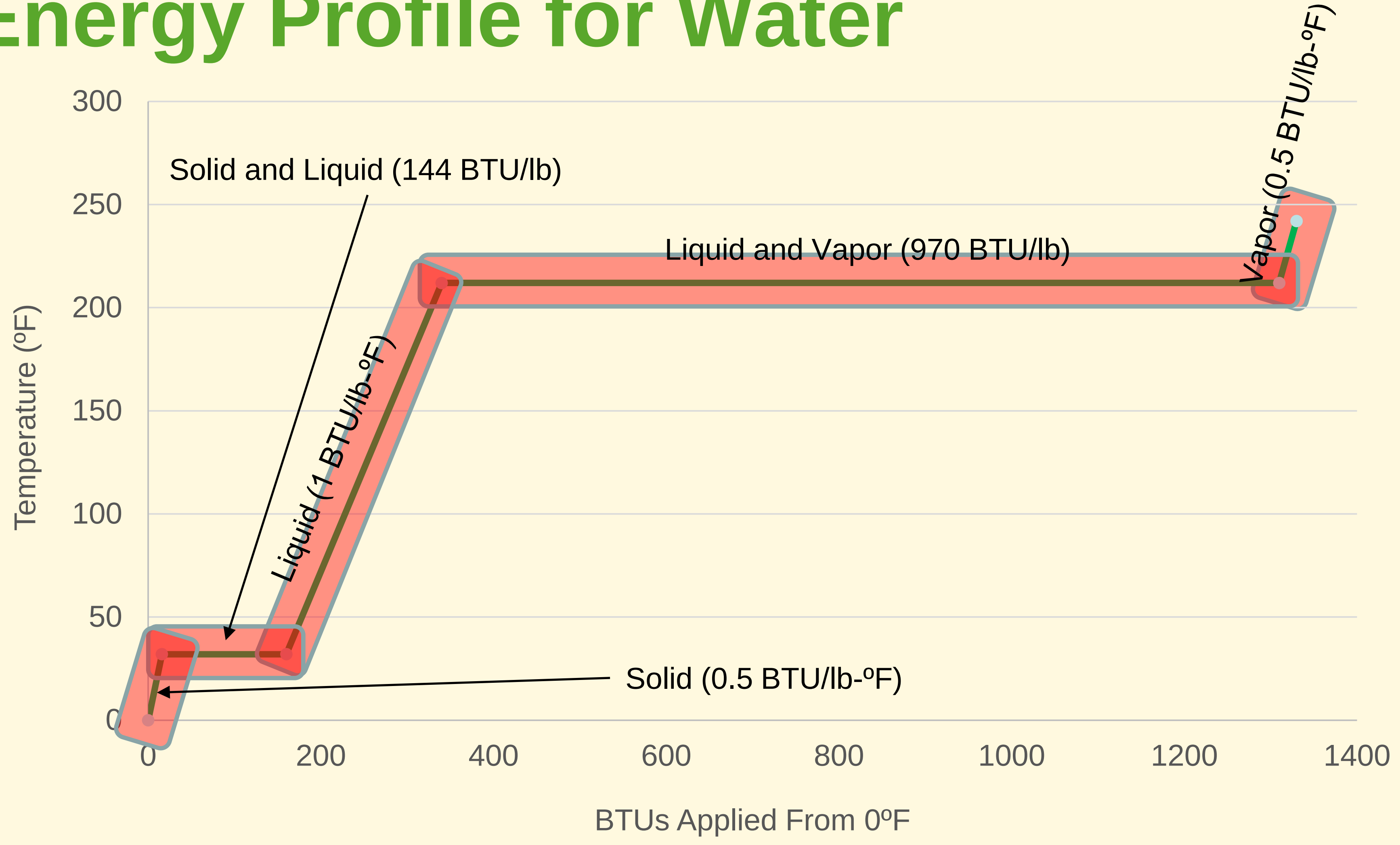
- Where:
  - Q_{Total} = total heat required (BTU)
  - $Q_{Sensible}$ = sensible heat (BTU)
  - Q_{Latent} = latent heat (BTU)

Example 4

- Determine the BTUs required to boil 2 lb of 40ºF water into steam.

$$Q_{Total} = Q_{Sensible} + Q_{Latent}$$
$$Q_{Sensible} = M \times C \times \Delta T$$
$$Q_{Latent} = M \times h_L$$
$$Q_{Total} = (M \times C \times \Delta T) + (M \times h_L)$$
$$Q_{Total} = \left(2lb \times 1\frac{BTU}{lb \cdot ºF} \times (212ºF - 40ºF)\right) + (2lb \times 970\frac{BTU}{lb})$$
$$\underline{\boldsymbol{Q_{Total} = 2,284BTU}}$$

Heat Energy Profile for Water



Example 5

- Determine the BTUs required to freeze 2,000 lb (1 ton) of 32ºF water into ice.

$$Q = M \times h_L$$

$$Q = 2{,}000lb \times 144\frac{BTU}{lb}$$

$$\underline{\boldsymbol{Q = 288{,}000\ BTU}}$$

Example 6

- If 2,000 lb of ice must be formed in 24 hours, what is *rate of heat transfer*?

$$\dot{Q} = \frac{Q}{t}$$

$$\dot{Q} = \frac{288{,}000BTU}{24hr}$$

$$\dot{Q} = 12{,}000\frac{BTU}{hr}$$

$$\underline{\boldsymbol{\dot{Q} = 1\,Tr}}$$

Refrigeration Tonnage

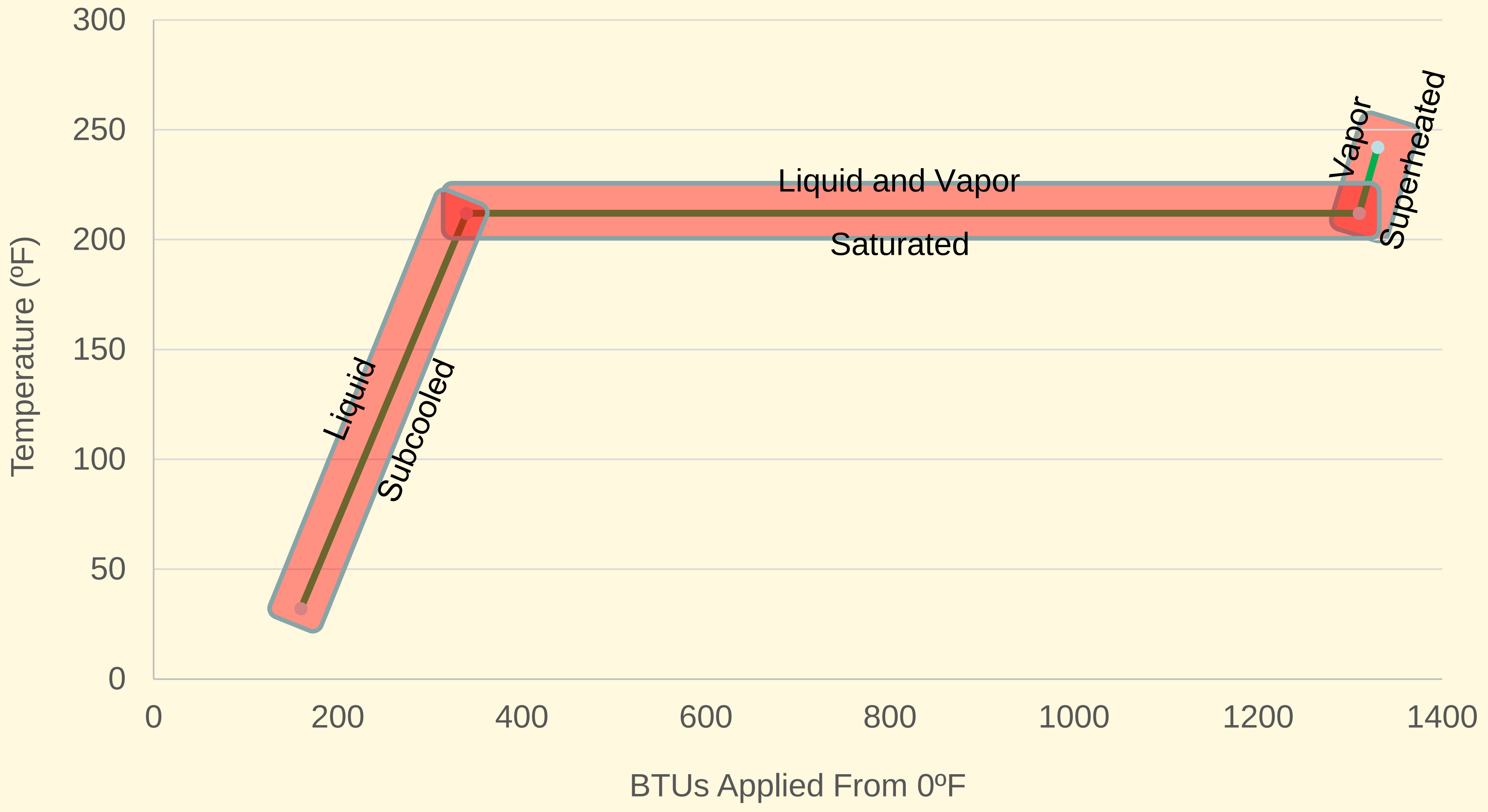
- 1 Ton of Refrigeration (Tr) is defined as the amount of heat required to freeze 2,000 lb of 32ºF water into ice.
- 1 Tr = 12,000 BTU/hr

Phase Changes

- **Boiling Point** – At a given pressure, the temperature at which a substance changes from a liquid to a vapor
- **Saturation** – When a substance is at its boiling temperature and is a liquid, vapor, or mixture between the two, it is saturated
- **Superheated Vapor** – A vapor that has increased in temperature after all of the liquid has boiled away without a change in pressure
- **Subcooled Liquid** – A liquid that exists below its saturation temperature

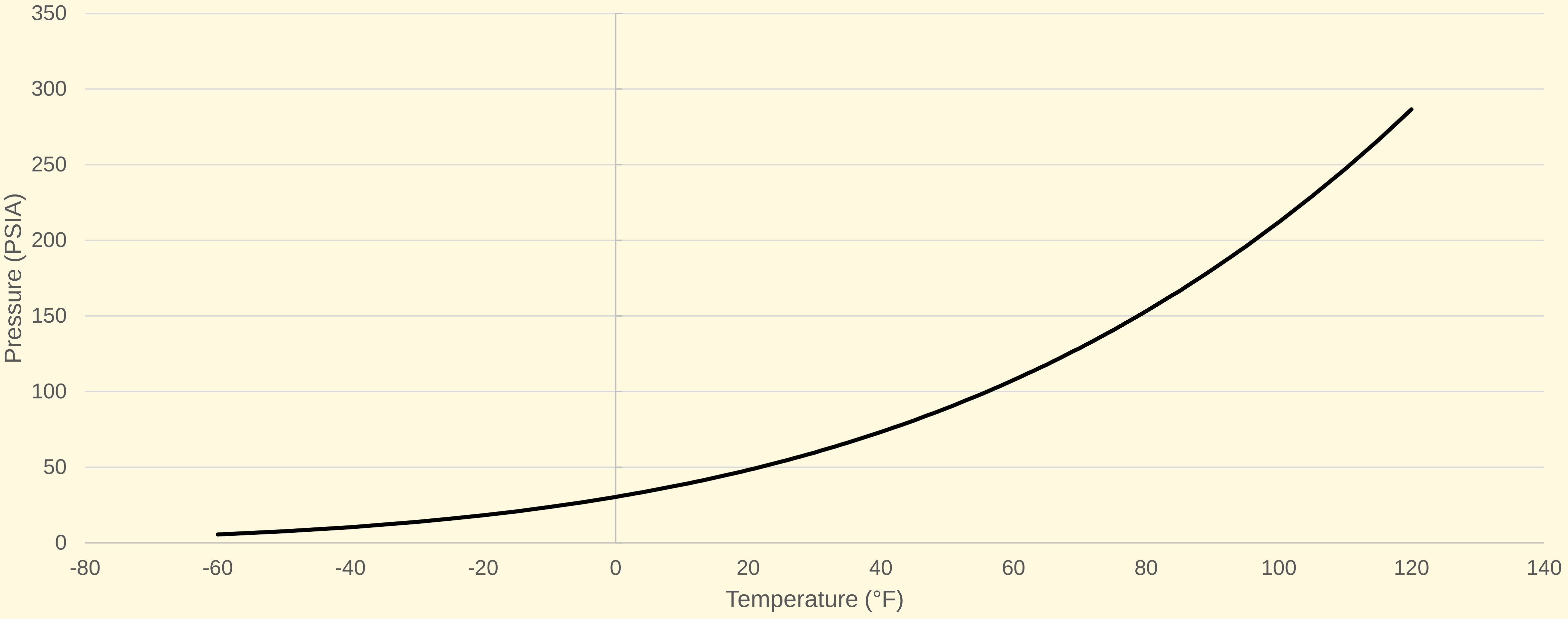
Providing Solutions. Simplifying Regulation.

Heat Energy Profile



Providing Solutions. Simplifying Regulation.

Pressure / Temperature Relationship



Properties of Refrigerants

- Saturated temp/press
- Density of liquid
- Density of gas
- Heat content of liquid
- Heat content of gas
- Specific volume of liquid
- Specific volume of gas
- Corrosive characteristics
- Toxicity
- Flammability
- Reactivity

Modes of Heat Transfer

- **Conduction** – The process of transferring heat through direct contact
- **Convection** – The process of transferring heat through a moving fluid
- **Radiation** – The process of transferring heat without a molecule to molecule direct exchange of energy

Questions?

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