ARTG-GDL1

DRAFT GUIDELINE (TRIAL USE)

Ammonia Refrigeration Training Guideline

Publication of this draft guideline for trial use and comment was approved by the International Institute of Ammonia Refrigeration and the Refrigerating Engineers & Technicians Association, October, 2005. Distribution of this draft guideline for comment shall not continue beyond June 30, 2009.

Foreword

Background

There is broad recognition that ammonia refrigeration systems exist in many different configurations, sizes and types of facilities. It is also widely recognized that personnel responsible for operation of refrigeration systems (sometimes referred to as "operators", "technicians", "engineers", "mechanics", etc.; hereafter referred to as operators) have significantly different roles and responsibilities in different facilities. More importantly, the industry at large has come to understand the importance of effectively training system operators. Furthermore, the industry believes that training guidelines identifying the areas of study and learning objectives for training system operators eliminates confusion and provides a road map for companies struggling with the task of meeting governmental regulations. This training guideline identifies the core competencies in an effective training program.

There currently exist many examples of training *best practices* available to the industry. These *best practices* are drawn from many different training venues that exist across the industry and include training programs developed by end users; organizations such as RETA (Refrigerating Engineers & Technicians Association); IIAR (International Institute of Ammonia Refrigeration), colleges/technical schools; and programs conducted by contractors and training consultants.

The development of this Ammonia Refrigeration Training Guideline is in response to the industry's call for such a resource. This collection of best training practices is purposely presented only as a guideline. While a standard-like review and comment by balanced interest groups was used to ensure that the guideline has broad industry support, this document should not be interpreted or represented as a formal industry standard.

Use of the Training Guideline

The learning objectives listed in this Guideline represent the consensus of a representative ammonia refrigeration industry group that included consultants, contractors, educators, and end-users. The Guideline is intended for use by companies developing new training programs or evaluating existing programs, and by training providers developing or offering training programs. While no current training program includes all of the elements contained in this guideline, it is hoped that all employers of ammonia refrigeration system operators as well as training providers will carefully review their training programs and curricula to ensure that the programs address the relevant learning objectives and competencies.

It is understood that regulatory agencies may use this guideline to evaluate whether a particular ammonia refrigeration facility has adequately trained its operators. Facilities that have used the Guideline for internal self-evaluation will be well prepared for such outside reviews.

The Guideline is intended to apply to the majority of typical ammonia refrigeration systems. However, because of the wide variety of systems existing in the industry, certain portions of the Guideline may not be applicable to some facilities. For example, references to Process Safety Management (PSM) and Risk Management requirements may not apply to some facilities. Facilities are encouraged to use their professional judgment as they review and consider the Guideline. The key is to ensure that the refrigeration operators are adequately trained.

The industry has endorsed the concept of multiple skill levels for its operators, with most firms recognizing three skill levels. Accordingly, this Guideline supports a multi-level approach by grouping learning objectives and competencies by level. It is recognized that a minority of operators will complete the highest skill level training. In some facilities, the responsibilities and duties requiring such training are handled by supervisory personnel, engineering staff or outside contractors and consultants rather than by operational staff. However, individuals carrying out these responsibilities should still be trained in the competencies listed for this level.

The OSHA Process Safety Management — PSM standard (and its EPA cousin, the Risk Management — RM — regulation) both require ammonia refrigeration facilities to have written operating procedures and to provide training to operators on an overview of the process and on those procedures. This training is not the same as the training covered by this Guideline. This Guideline discusses overall educational job competencies, while PSM/RM covers only the narrow performance of specific regulated job tasks.

This Guideline is not intended to substitute for PSM/RM training, nor can training in a small number of operating procedures replace a broad base of refrigeration knowledge. Do not assume that following this Guideline constitutes "PSM training."

Some small facilities may not be required to comply with PSM/RM. These facilities may still find it beneficial to prepare and use operating procedures in their plants. Both OSHA and EPA enforce so-called "general-duty clauses" calling upon them to handle chemicals such as refrigerants with due care. Written operating procedures can be of help in this, if operators are trained in their use.

The guideline assumes that an experienced trainer familiar with the curriculum that addresses these learning objectives will provide operator training. In addition to having quality training materials and instructors, it is recommended that an appropriate assessment be conducted to measure training effectiveness. A thorough evaluation and verification of training effectiveness may include verbal testing, written testing, certification programs, documentation of prior education/training and/or hands-on site-specific demonstration of competencies.

It should also be noted that this industry-wide guideline primarily addresses classroom-type training. Such training is supplemental to the critical hands-on, facility-specific training that should cover detailed operating procedures for the various system components that comprise a working ammonia refrigeration system. The limited mention of such hands-on training associated with those operating procedures should not be taken as an indication that it is any less important than the learning objectives included in this guideline.

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AMMONIA REFRIGERATION TRAINING GUIDELINE

PURPOSE

This Guideline provides a set of recommended training objectives for personnel responsible for the operation of ammonia refrigeration systems (operators, technicians, engineers, mechanics, etc.; hereafter referred to as operators). Such training promotes the safe, efficient, and cost-effective operation of ammonia refrigeration systems and equipment.

SCOPE

This Guideline lists refrigeration-specific concepts, skills, knowledge, and competencies (presented as learning objectives) that should be included in training programs for ammonia refrigeration operators. Training addressing these learning objectives should be combined with hands-on training focused on the various system and equipment-specific written operating procedures. The learning objectives provided herein will provide the knowledge needed to properly understand such operating procedures and to enhance decision-making abilities of the operator.

This Guideline also provides a recommended list of non-refrigeration, facility-specific training that is recommended background training for individuals prior to commencing formal refrigeration operator training, but does not list specific training objectives for these topics.

This Guideline does not prescribe specific curriculum materials or training methods.

OPERATOR CLASSIFICATIONS

The learning objectives in this Guideline are divided down into the following suggested skill level classifications:

- Entry
- Operational
- Technical

It is recognized that some facilities may use a different approach to skill levels and this Guideline is not meant to discourage such approaches. The guideline is purposely structured to be readily modified to rearrange the learning objectives into fewer or more levels.

The Recommended Prerequisite Training section represents the recommended minimum set of skills, knowledge and competencies for any person entering training as an ammonia refrigeration operator.

The learning objectives for the **Entry** skill level represent a recommended set of skills, knowledge and competencies for personnel who:

- Observe refrigeration system operations
- Record pertinent operation parameters
- Take control actions only under direct supervision of a supervisor or Operational level personnel

The learning objectives for the **Operational** skill level represent a recommended set of skills, knowledge and competencies for personnel who:

- Have successfully performed at the Entry Level
- Start and stop equipment
- Adjust controls, actuate valves
- Perform routine system maintenance
- Assist in training of Entry level personnel
- Perform system troubleshooting

The learning objectives for the **Technical** skill level represent a recommended set of skills, knowledge and competencies for personnel who:

- Have successfully performed at the Operational Level
- Make decisions regarding operating strategies, setpoints, and limits
- Optimize system operations for improved cost and reliability
- Schedule and/or perform major repairs and rebuilds
- Recommend system upgrades and improvements
- Perform system inspections and mechanical integrity checks
- Participate extensively in the Process Safety Management program
- Perform complex troubleshooting
- Oversee or inspect system construction/installation activities
- Supervise Operational and Entry level operators
- Coordinate shutdowns and pumpdowns
- Administer preventive and predictive maintenance systems

The classifications are intended for guidance only, and are not intended to suggest that operational duties must be organized into these three levels. Users whose staffs are organized differently should document the duties and corresponding training objectives associated with their own set of classifications.

PREREQUISITE TRAINING AND SKILLS ASSESSMENT

This document assumes that the prospective operator trainee has been assessed for basic abilities and tendencies that are widely accepted as being prerequisites for becoming an operator. There are a number of skill and/or aptitude assessment tools available. In order to be ready to receive the training outlined in this guideline, a good candidate for the job of a refrigeration system operator would typically have the following aptitudes and knowledge base:

- Strong mechanical aptitude
- Basic mechanical skills and knowledge of machinery
- Basic electrical skills

- Basic communication skills
- Basic math skills
- Basic computer skills

Appendix A provides additional information on one approach to pre-employment screening.

This document is also based on a collection of assumptions about prior skill screening and training not specific to ammonia refrigeration system operators. Such training — not covered by this Guideline — is subject to federal, state and local regulations as well as a company's human resource policies.

Examples of such training are as follows:

- Lock-Out/Tag-Out
- Fall Protection
- Hearing and Eye Protection
- Hazard Communication Standard (HAZCOM)
- Personal Protective Equipment (PPE)
- Site and Product Security
- Emergency Action Plan
- Communication Skills

The required communication skills may include the ability to read and understand operating procedures; to fill out operating logs and system status reports; and to orally communicate with co-workers and with emergency personnel, to describe the current system status and the nature and location of dangerous or abnormal conditions.

The trainee should also be fully aware of any facility security requirements such as identification cards, controlled access areas, traffic policies, and general evacuation and emergency notification procedures.

Lastly, it is assumed that the candidate has received appropriate familiarization and orientation concerning the nature of the business done at the facility, any production processes that may take place in the facility and any other typical employee orientation.

Upon successful completion of the above-described orientation and training, the refrigeration system operator trainee should be ready for the specialized training described in this Guideline.

ASSESSMENT OF TRAINING EFFECTIVENESS

Assessment is a key success factor for any curriculum. The application of reliable and accurate pre-assessment tools determines a learner's appropriate "fit" into a curriculum, having both the pre-requisite skills necessary to complete the curriculum, and the personal interest and aptitude to do so. Ongoing assessment within the instructional modules can inform the student of progress as well as provide feedback for selecting individual learning strategies and achieving program-learning goals. Likewise, proper post-instructional assessment assures learners have demonstrated the knowledge, skills and abilities of the program's terminal objectives. The following methods may be used for measuring a trainee's understanding of each learning objective, but are not meant or intended to be all-inclusive. Assessments should be documented.

Written Achievement Tests: Questions designed to verify the trainee's comprehension of the subject matter should be included in a traditional achievement test. True/False, Multiple Choice, and Essay are acceptable types.

Verbal/Oral Exam — Interview: Verbal questions designed to verify the trainee's comprehension of the subject matter should be included in an oral exam administered by an individual knowledgeable in the subject matter.

Demonstration/Performance Exam: The trainee should be able to demonstrate the acquired knowledge by performing tasks that require said knowledge. The Performance Exam should be administered and supervised by an individual knowledgeable in the subject matter.

The Appendix contains an extensive listing of resources that may be helpful in the preparation of a curriculum needed to provide effective instruction relative to these learning objectives.

Learning Objectives for Effective Refrigeration Operator Training Programs

This section is a collection of Learning Objectives that are segregated into general topical areas and then into three different Classification levels. The individual Learning Objectives are not meant to itemize every detailed concept or task that training should address. Rather, they are intended to represent a collection of related subjects that would typically be covered together. The numbering system for the Learning Objectives is solely for the purpose of organization and does not represent or dictate a specific order of priority.

The Learning Objectives are brief statements describing the topic content that the trainee is expected to learn and understand.

1.0 General Facility Information (see also Process Safety Information)

1.1 (Entry):

1.1.1 Ammonia-related site security including ammonia theft prevention

1.1.2 Location, operation and use of Personal Protective Equipment (PPE)

1.1.3 Alarming procedures, evacuation routes, assembly points

1.1.4 Importance of refrigeration to production processes

1.1.5 Implications of refrigeration failure

1.1.6 Layout/location of refrigerated spaces and processes

1.1.7 Locations of Machinery Rooms and other equipment

1.2 (Operational):

1.2.1 Product quality assurance programs associated with refrigeration—Handling and documentation of deviations-who to contact

1.2.2 Environmental (temperature/humidity) requirements of refrigerated spaces

1.3 (Technical):

1.3.1 Non-refrigeration process P&IDs that interface with the refrigeration system

2.0 Engineering Units and Conversions

2.1 (Entry):

2.1.1 Units of measure—pressure (including vacuum), temperature

2.1.2 Conversion from one system of measure to others that will be encountered

2.2 (Operational):

2.2.1 Units of measure for energy (work), power, refrigeration tonnage, density (and specific gravity), specific volume and various measure of humidity

2.2.2 Units of measure for volumetric and mass flows

2.2.3 Conversion from one system of measure to others that will be encountered

2.3 (Technical):

2.3.1 Units of measure unique to refrigeration systems such as kW and bhp per ton, mass flow rate of refrigerant per ton (lb/min-TR), compressor capacity expressed in cfm per ton

2.3.2 Conversion from one system of measure to others that will be encountered

3.0 Refrigeration Thermodynamics

3.1 (Entry):

3.1.1 Basic phase changes that substances undergo

3.1.2 Predictable relationship between temperature and pressure of a pure substance when liquid and vapor phases are present (use of Pressure Temperature (PT) Tables)

3.1.3 Basic concept of heat transfer

3.1.4 Basic psychrometric properties (dry bulb, wet bulb, relative humidity)

3.1.5 Basic understanding of condensation/frost build-up and implications

3.1.6 Basic concept of fluid flow (high to low, pressure drop with flow)

3.1.7 Awareness of behavior of brine and glycol solutions

3.1.8 Basic Pressure Enthalpy (PH) diagrams

3.2 (Operational):

3.2.1 Concept of "specific heat," typical units of measure

3.2.2 Specific heats of pertinent substances

3.2.3 Relationship between specific heat and "heat capacity"

3.2.4 Sensible Heat portion of the total refrigeration load

3.2.5 Awareness of calculations of Sensible Heat Load

3.2.6 Latent heat of fusion (freezing/thawing)

3.2.7 Latent heat of vaporization (evaporation/condensation)

3.2.8 Latent heat portion of the total refrigeration load

3.2.9 Modes of heat transfer—conduction, convection (and radiation)

3.2.10 Parameters affecting heat transfer (phase changes, velocity)

3.2.11 Conductors and insulators

3.2.12 Pressure drop due to flow or elevation change

3.2.13 Pressure drop tables for flowing ammonia refrigerant vapor and liquid

3.2.14 Basic pipe sizing using tables

3.2.15 Beneficial pressure drop

3.2.16 Detrimental pressure drop and associated negative impacts

3.2.17 Basic implications of Pressure/Volume/Temperature (P/V/T) relationships for ammonia vapor

3.2.18 Properties of brines and glycols

3.3 (Technical):

3.3.1 Tables of specific heats of common substances and sense of the typical values of specific heats for different categories of substances such as fluid solutions, metals, foods, and gases

3.3.2 Detailed Sensible Heat Load calculations

3.3.3 Tables of latent heats of fusion for commonly frozen substances

3.3.4 Latent heat of vaporization as found in thermodynamic property tables

3.3.5 Calculation of Latent Heat Load

3.3.6 Calculation of transmission loads, infiltration loads, motor loads and respiration loads

3.3.7 Calculation of Total Heat Load

3.3.8 Typical conduction and convection heat transfer coefficient ranges

3.3.9 Effects of fouling and scaling

3.3.10 Basic formulas for each type of heat transfer:

- **3.3.10.1** Types of heat transfer coefficients: thermal resistance R, convection coefficient h, emittance e
- **3.3.10.2** Conditions or characteristics that lead to increases or decreases in heat transfer coefficients

3.3.11 Piping system pressure drop calculations

3.3.12 Reducing piping pressure drop

3.3.13 Detailed understanding of PVT relationships for ammonia vapor

3.3.14 Psychrometric processes and chart usage:

- **3.3.14.1** Air chilling/conventional dehumidification
- **3.3.14.2** Conditions for frost formation
- **3.3.14.3** Specialized dehumidification — reheat, dessicants

4.0 Mechanical Vapor Compression Refrigeration Cycle

4.1 (Entry):

4.1.1 Cycle comprised of four thermodynamic processes:

4.1.1.1 Basic evaporation process

4.1.1.2 Basic compression process

4.1.1.3 Basic condensation process

4.1.1.4 Basic expansion (throttling) process

4.2 (Operational):

4.2.1 Evaporation Process:

4.2.1.1 Role of evaporation process

4.2.1.2 Impact of inadequate liquid supply

4.2.1.3 Impact of frost build-up

4.2.1.4 Impact of temperature differential

4.2.1.5 Impact of contaminants including water

4.2.1.6 Superheat

4.2.2 Compression Process:

4.2.2.1 Role of compression process

4.2.2.2 Impact of liquid carryover

4.2.2.3 Energy input (electric motor/ gas engines)

4.2.2.4 Compression ratio

4.2.2.5 Brake horse power per ton

4.2.2.6 Two-stage compression with intercooling

4.2.2.7 Compressor displacement/ volumetric efficiency

4.2.3 Condensation Process:

4.2.3.1 Role of condensation process

4.2.3.2 Impact of non-condensibles

4.2.3.3 Impact of desuperheating

4.2.3.4 Impact of subcooling

4.2.3.5 Impact of temperature differential

4.2.4 Expansion Process:

4.2.4.1 Role of expansion process

4.2.4.2 Impact of subcooling

4.2.4.3 Flash gas generation

4.3 (Technical):

4.3.1 Representation of refrigeration cycle on P-H diagram:

4.3.1.1 Single stage compression

4.3.1.2 Two-stage compression with intercooling

4.3.2 Correlation of diagram with Thermodynamic Property Tables

4.3.3 Calculations related to refrigeration cycle:

4.3.3.1 Theoretical horsepower per ton

4.3.3.2 Cfm per ton (theoretical and actual)

4.3.3.3 Lb/min per ton refrigerant flow

4.3.3.4 Flash gas fraction

4.3.3.5 Coefficient of Performance (COP)

4.3.4 Typical refrigeration system application parameters (Ammonia Data Book Appendix B)

5.0 System Energy Efficiency

5.1 (Entry):

5.1.1 Effect of condensing pressure/ temperature

5.1.2 Effect of suction pressure/temperature

5.1.3 Evaporative condenser winter operation

5.2 (Operational):

5.2.1 Effect of evaporator and condenser temperatures on compression work

5.2.2 Effect of temperature differentials between ammonia and process load

5.2.3 Effect of temperature differentials between ammonia and ambient

5.2.4 Liquid subcooling benefits

5.2.5 Vapor superheating issues

5.2.6 Efficient flash gas removal

5.2.7 Two-stage vs. single stage compression

5.2.8 Multiple suction pressure systems

5.2.9 Impact of compressor economizer/ side port use

5.2.10 Fan power/application of variable speed drives and 2 speed motors

5.2.11 Benefits of effective purging/ noncondensible elimination

5.2.12 Part-load operation of compressors

5.3 (Technical):

5.3.1 Demand management strategies including process scheduling and thermal storage

5.3.2 Optimization of evaporator temperature differentials—design and operation

5.3.3 Optimization of condenser temperature differentials—design and operation

5.3.4 Efficiency measures—bhp/TR, kW/TR, COP

5.3.5 Optimization of component (ie. compressors, condensers, etc) sequencing

6.0 Ammonia as a Refrigerant

6.1 (Entry):

6.1.1 Choice of ammonia as system refrigerant

6.1.1.1 Environmental advantages

6.1.1.2 Detectability—Self-alarming quality

6.1.1.3 Cost and availability

6.2 (Operational):

6.2.1 Operational Advantages:

6.2.1.1 Cycle efficiency

6.2.1.2 Lower mass flows

6.2.1.3 Tolerance for contamination

6.2.1.4 Favorable operating pressure range

6.2.2 Thermodynamic properties:

6.2.2.1 Familiarity with saturation tables

6.2.3 Corrosion considerations

6.2.4 Ammonia and Water:

6.2.4.1 Affinity for moisture

6.2.4.2 Discharging ammonia into water

6.2.4.3 Water's effect on evaporating temperature

6.2.5 Oil solubility in ammonia

6.2.6 Ammonia releases to the environment

6.3 (Technical):

6.3.1 Ammonia Pressure-Enthalpy (Mollier) Diagram:

6.3.1.1 Vapor dome and mixture quality

6.3.1.2 Saturated liquid line

6.3.1.3 Saturated vapor line

6.3.1.4 Superheat region

6.3.2 Superheated vapor property tables

6.3.3 Ammonia-water solutions—pH

7.0 Process Safety Information

7.1 (Entry):

7.1.1 Ammonia Properties, Health Effects and Hazards

7.1.2 Personal Protective Equipment

7.1.3 Concentration Measurement

7.1.4 Flammability Issues

7.1.5 Ammonia Inventory Awareness

7.1.6 Block flow or Process Flow Diagrams

7.1.7 P&ID awareness

7.1.8 Operating limits

7.1.9 Implications of deviations outside operating limits

7.1.10 Compatibility—materials of construction

7.1.11 Controls—cutouts, alarms, detectors

7.1.12 Relief system awareness

7.1.13 Ventilation system awareness

7.1.14 Electrical classification awareness

7.1.15 Mass and energy balance awareness

7.1.16 Design code and standard awareness

7.2 (Operational):

7.2.1 Working knowledge of P&IDs

7.3 (Technical):

7.3.1 Ammonia inventory calculations

7.3.2 Relief system design basis/calculations

7.3.3 Ventilation system design basis/calculations

7.3.4 Design codes and standards

7.3.4.1 Mechanical

7.3.4.2 Fire

7.3.4.3 Electrical

7.3.4.4 Pressure Vessels

8.0 Evaporators-Description, Theory of Operation and Maintenance

8.1 (Entry):

8.1.1 Types of evaporators:

8.1.1.1 Shell and tube (flooded and direct expansion)

8.1.1.2 Plate and frame (flooded and direct expansion)

8.1.1.3 Falling film plate chillers

8.1.1.4 Ice builders and ice makers/harvesters

8.1.1.5 Hydro-coolers

8.1.1.6 Plate freezers

8.1.1.7 Swept surface heat exchangers

8.1.1.8 Fan coil air units (forced and induced draft units)

8.1.1.9 Other

8.2 (Operational):

8.2.1 Evaporator isolation and pump-out procedures

8.2.2 Defrost methods for air units

8.2.3 Maintaining evaporator efficiency

8.2.4 Safety considerations for evaporators

8.2.5 Evaporator troubleshooting

8.3 (Technical):

8.3.1 Capacities of evaporators

8.3.2 Proper and improper applications

9.0 Compressors-Description, Theory of Operation and Maintenance

9.1 (Entry):

9.1.1 Different compressor categories:

9.1.1.1 Positive displacement compressors

9.1.1.2 Dynamic (centrifugal) displacement compressors

9.1.2 Different types of compressors:

9.1.2.1 Rotary screw

9.1.2.2 Reciprocating piston

9.1.2.3 Vane rotary

9.1.2.4 Other

9.1.3 Basic theory of compressor operation

9.1.4 Effect of a liquid *slug* on a positive displacement compressor

9.1.5 Impact of different conditions such as warm start-up on the operation of the compressor

9.1.6 Compressor rotation direction

9.1.7 Types of compressor drive arrangements

9.1.8 Typical safe operating limits

9.1.9 System specific list/description of compressors in use

9.2 (Operational):

9.2.1 Various methods of starting and stopping compressors

9.2.2 Compressor isolation and pump-out procedures

9.2.3 Compressor safety controls

9.2.4 Lubrication methods/systems

9.2.5 Correct method of adding and draining oil from compressors

9.2.6 Oil sampling and analysis

9.2.7 Oil separation methods

9.2.8 Oil filtration systems

9.2.9 Causes and effects of refrigerant migration to compressors

9.2.10 Effect of suction vapor superheat on the compressor

9.2.11 Various types of oil cooling:

9.2.11.1 Water or glycol cooled

9.2.11.2 Thermosyphon

9.2.11.3 Liquid injection

9.2.11.4 Other

9.2.12 Compressor oil dynamics

9.2.13 Operation of the economizer (side) port

9.2.14 Part-load characteristics of compressors

9.2.15 Compressor relief arrangement and why it is needed

9.2.16 Discharge check valves

9.2.17 Compressor control system

9.2.18 Compressor troubleshooting

9.3 (Technical):

9.3.1 Compressor motor installation and/or replacement

9.3.2 Alignment procedures

9.3.3 Vibration monitoring and/or analysis

9.3.4 Compressor shaft seals

9.3.5 Volumetric and compression efficiency characteristics

9.3.6 Compressor overhaul/rebuild considerations

9.3.7 Compressor mass/energy balances

10.0 Condensers-Description, Theory of Operation and Maintenance

10.1 (Entry):

10.1.1 Different condenser types:

10.1.1.1 Evaporative condensers

10.1.1.2 Water-cooled condensers

10.1.1.3 Air-cooled condensers

10.1.1.4 Other

10.1.2 System specific list/descriptions of condensers in use

10.2 (Operational):

10.2.1 Maintaining the condenser system

10.2.2 Condenser capacity and operational control:

10.2.2.1 Summer vs. winter operation

10.2.2.2 Single speed vs. two speed vs. VFD

10.2.2.3 Flow control on water-cooled

10.2.3 Condenser isolation and pump-out procedures

10.2.4 Water makeup/blowdown systems

10.2.5 Water treatment systems and fouling

10.2.6 Condenser troubleshooting

10.3 (Technical):

10.3.1 Condenser mass/energy balance

11.0 Metering Devices-Description, Theory of Operation and Maintenance

11.1 (Entry):

11.1.1 Types of metering devices:

11.1.1.1 Hand metering valves

11.1.1.2 Float-actuated valves

11.1.1.3 Modulating valves

11.1.1.4 Fixed orifices

11.1.1.5 Thermal expansion valves

11.1.1.6 Other

11.2 (Operational):

11.2.1 Metering device troubleshooting

11.2.1 Metering device maintenance and rebuilds

11.3 (Technical):

11.3.1 Capacities of metering devices

11.3.2 Proper and improper applications

12.0 Pressure Vessels-Description, Theory of Operation and Maintenance

12.1 (Entry):

12.1.1 Function of the pressure vessels:

12.1.1.1 Pump receivers

12.1.1.2 High pressure receivers

12.1.1.3 Surge drums

12.1.1.4 Intermediate vessels

12.1.1.5 Oil pots

12.1.1.6 Suction accumulators

12.1.1.7 Oil Separators

12.1.1.8 Thermosyphon receiver

12.1.1.9 Controlled pressure receivers

12.1.1.10 Other

12.1.2 Acceptable operating pressure and level limits

12.2 (Operational):

12.2.1 Pressure vessel maintenance

12.2.2 Pressure vessel troubleshooting

12.3 (Technical):

12.3.1 Requirements for coded vessels

12.3.2 Gas/liquid separation

13.0 Piping and Accessories-Description, Theory of Operation and Maintenance

13.1 (Entry):

13.1.1 Categories of piping:

13.1.1.1 Liquid

13.1.1.2 Discharge vapor

13.1.1.3 Suction vapor

13.1.1.4 Two-phase flow

13.1.1.5 Other

13.1.2 Pipe labeling

13.2 (Operational):

13.2.1 Piping system troubleshooting:

13.2.1.1 Noise

13.2.1.2 Movement

13.2.1.3 External corrosion

13.2.2 Minimizing risk of physical impact/damage

13.2.3 Insulation maintenance:

13.2.3.1 Vapor barrier

13.2.3.2 Physical damage

13.2.4 Line opening procedures including system re-start

13.2.5 Types of service valves:

13.2.5.1 Angle valves

13.2.5.2 Globe valves

13.2.5.3 Ball valves

13.2.5.4 Butterfly valves

13.2.5.5 Other

13.2.6 Operation and maintenance of service valves:

13.2.6.1 Opening and closing

13.2.6.2 Trapped liquid

13.2.6.3 Packing

13.2.6.4 Other

13.2.7 Safety relief system:

13.2.7.1 Compressor

13.2.7.2 Relief discharge piping

13.2.7.3 Pressure vessel

13.2.7.4 Hydrostatic relief

13.2.7.5 Other

13.3 (Technical):

13.3.1 Piping component replacement

13.3.2 Mechanical integrity inspections

13.3.3 Piping materials, types, and pressure/temperature ratings

14.0 Liquid Ammonia Pumps-Description, Theory of Operation and Maintenance

14.1 (Entry):

14.1.1 Pump Types:

14.1.1.1 Positive displacement

14.1.1.2 Centrifugal

14.1.1.3 Mechanical seals vs. seal-less

14.2 (Operational):

14.2.1 Liquid ammonia pump safety features

14.2.2 Operation and maintenance of liquid ammonia pumps

14.2.3 Liquid ammonia pump troubleshooting

14.3 (Technical):

14.3.1 Proper and improper applications (including use of pump curves/charts)

15.0 Controls and Control Valves-Description, Theory of Operation and Maintenance

15.1 (Entry):

15.1.1 Types:

15.1.1.1 Solenoid valves

15.1.1.2 Downstream pressure regulators

15.1.1.3 Back pressure regulators

15.1.1.4 Check valves

15.1.1.5 Motorized or modulating valves

15.1.1.6 Awareness of programmable logic controller (PLC) and microprocessor-based controls

15.1.1.7 Other

15.1.2 Functions of each type

15.2 (Operational):

15.2.1 Operation and maintenance of control valves:

15.2.1.1 Procedures for testing safety controls (e.g. high-level cutouts)

15.2.2 Control and/or automation/information systems:

15.2.2.1 Microprocessors

15.2.2.2 Relays, timers, switches

15.2.2.3 PLCs

15.2.2.4 Other

15.2.2.5 Consequences of failure

15.2.2.6 Troubleshooting

15.3 (Technical):

15.3.1 Sizing of control valves

15.3.2 Advanced troubleshooting using automation/information systems

16.0 Motors and Drives-Description, Theory of Operation and Maintenance

16.1 (Entry):

16.1.1 Types of motor enclosures

16.1.2 Motor alignment

16.1.3 Bearing lubrication

16.1.4 Full load amps

16.1.5 Rotation

16.1.6 Speeds available

16.2 (Operational):

16.2.1 Wiring

16.2.2 Hot starts per hour

16.2.3 Motor service factor

16.2.4 Loaded start

16.2.5 Awareness of starter types—full voltage, reduced voltage, incremental

16.2.6 Unbalanced voltages

16.2.7 Voltage tolerance

16.2.8 Surge voltage

16.2.9 Starter transition times

16.2.10 Auxiliary contacts

16.2.11 Gear boxes

16.2.12 Variable frequency drives

16.3 (Technical):

16.3.1 Motor selection criteria

16.3.2 Starter type details and troubleshooting

16.3.3 Mechanical drives-engines, turbines

17.0 Purgers-Description, Theory of Operation and Maintenance

17.1 (Entry):

17.1.1 Basic awareness of non-condensibles and purging

17.2 (Operational):

17.2.1 Sources, impacts, and detection of non-condensible gases

17.2.2 Basic operation of automatic and manual purgers

17.2.3 Manual removal of non-condensibles

17.3 (Technical):

17.3.1 Proper and improper applications

18.0 Other Components-Description, Theory of Operation and Maintenance

18.1 (Entry):

18.1.1 Awareness of manual overpressure control systems

18.1.2 Awareness of insulation and vapor barrier systems

18.1.3 Awareness of freezer underfloor heating systems

18.1.4 Awareness of freezer enclosure venting during rapid pull-down

18.2 (Operational):

18.2.1 Operation and Maintenance:

18.2.1.1 Manual overpressure control system

18.2.1.2 Purpose of insulation and vapor barrier systems

18.2.1.3 Underfloor heating systems

18.2.1.4 Freezer enclosure vents

18.3 (Technical):

18.3.1 Proper and improper applications

19.0 Operating Procedures and Practices

19.1 (Entry):

19.1.1 Basic operating procedures

19.1.2 Use of automated systems

19.1.3 Routine monitoring and logging

19.1.4 Safe operating limits

19.1.5 Production-required operating limits

19.1.6 Alarms and proper response

19.1.7 Good housekeeping

19.1.8 Detection of leaks

19.2 (Operational):

19.2.1 Advanced operating procedures

19.2.2 Adding oil

19.2.3 Draining oil

19.2.4 Visual inspections for corrosion

19.2.5 Inspection of insulation

19.2.6 Causes and implications of hydraulic shock

19.2.7 Hazards of trapped liquid expansion

19.2.8 Manual operations caused by automation failures

19.2.9 Actions during power failure

19.2.10 Recovery from power failure

19.2.11 Special operations caused by extreme weather conditions

19.2.12 Charging system

19.2.13 Pumpdowns and pumpouts

19.2.14 Emergency operations and shutdowns

19.2.15 Manual purging

19.2.16 Assist in developing operating procedures

19.3 (Technical):

19.3.1 Non-destructive testing for corrosion

19.3.2 Identifying/correcting potential hydraulic shock situations

19.3.3 Identifying/correcting trapped liquid situations

19.3.4 Developing good operating procedures

20.0 Regulatory Awareness

20.1 (Entry):

20.1.1 Elements of the PSM and RM programs

20.1.2 General Duty Clause awareness

20.1.3 Location of program documents

20.1.4 Local, state and Federal reporting requirements

20.2 (Operational):

20.2.1 In-depth knowledge of the elements of the PSM and RM Programs

20.3 (Technical):

20.3.1 Administration of the PSM and RM programs

20.3.2 Record maintenance and storage

Appendix A
Pre-employment Screening

• Completion of successful training as an Industrial Refrigeration Operator requires a substantial commitment from the employee, as well as the company. The employer should discuss this commitment with prospective trainees.

• A prospective trainee must understand and agree that safety is the most important expectation of employment. All work performed will adhere to all OSHA, USEPA and plant safety regulations.

• A prospective trainee should demonstrate proficiency in applied technology skills, observation skills, locating information skills, reading for information skills, and applied mathematics skills, based on pre-employment screening.

The following information may be used as an aid in pre-employment screening, or as an aid for determining qualification of an existing employee who wishes to transfer to the role of an operator. An ACT (American College Testing) work keys profile study was conducted in 2001. This study involved testing and evaluating 29 refrigeration operators from 13 companies throughout the United States.

The results of this study indicate that prospective refrigeration operators should have the following minimum proficiencies:

- Applied Technology Level 4
- Observation Level 5
- Locating Information Level 4 to 5
- Reading for Information Level 4
- Applied Mathematics Level 5 to 6

DESCRIPTIONS OF PROFICIENCIES FOR PRE-EMPLOYMENT SCREENING

Applied Technology:

Level	Skills
3	Understand the operation of tools, machine components, and uncomplicated systems, such as piping systems, simple electric heaters, or other equipment found in the home, school, or workplace. Apply elementary principles underlying the operation of physical systems, such as the workings of plumbing components or uncomplicated electrical circuits.
4	Understand the operation of moderately complex tools, machines, and systems, such as appliances, pulley driven equipment, or piping systems that carry more than one fluid. Apply elementary principles underlying the operation of physical systems, such as block and tackle or cooling fins.
5	Apply physical principles to machines which have several components, perform complex operations, and sometimes interact with other systems. Understand complex machines and systems, such as the operation of gasoline engines, complex appliances, or an electrical system in a building.
6	Apply principles that affect certain properties of a system such as phase change or pressure equilibrium. Troubleshoot complex systems in which a variety of mechanical, electrical, thermal, or flow faults are potential sources of difficult problems.

Observation:

Level	Skills
3	Pay attention. Watch and listen to a strongly cued demonstration or set of instructions. Remember a few strongly reinforced details of a process or procedure.
4	Sustain focused attention on the demonstrated instructions, process, or procedure. Select and attend to important details. Remember a few important, moderately reinforced details about the demonstrated process or procedure.
5	Focus attention on and remember several important aspects of the information presented. Ignore irrelevant background information through selective attention to important details. Maintain attention to detail. Remember several important details about unfamiliar material.
6	Notice and remember several details that are relevant to the process or procedure being shown. Take in and recall incoming sensory information so it can be used to make predictions, comparisons, or evaluations. Visualize how a detail or task fits into the entire process or procedure demonstrated. Interpret if-then and cause-effect relationships.

Locating Information:

Level	Skills
3	Find one or two pieces of information in graphics such as simple order forms, bar graphs, tables, flowcharts, or floor plans. Fill in one or two pieces of information that are missing from these types of elementary graphics.
4	Find several pieces of information in workplace graphics such as basic order forms, line graphs, tables, instrument gauges, maps, flowcharts, and diagrams. Summarize and/or compare information and trends in a single graphic. Summarize and/or compare information and trends among more than one workplace graphic, such as a charge slip and an invoice showing related information; in order to accomplish this, the examinee must determine the relationship among the graphics.
5	Summarize and/or compare information and trends in a single complicated workplace graphic, such as detailed forms, tables, graphs, maps, instrument gauges, and diagrams. Summarize and/or compare information and trends among more than one workplace graphic, such as a bar chart and a data table showing related information; in order to accomplish this, the examinee must sort through distracting information.
6	Draw conclusions from the information presented in very detailed graphs, charts, tables, forms, maps, and diagrams. Apply information from these types of graphics to specific situations. Make decisions and/or predictions requiring judgments based on the information presented in these types of graphics; in order to accomplish this, the examinee must analyze the data within the graphics.

Reading For Information:

Level	Skills
3	Identify uncomplicated key concepts and simple details in basic reading materials, such as company policies, procedures, and announcements. Recognize proper placement of a step in a sequence of events, or the proper time to perform a task. Identify the meaning of a word that is defined within the text. Identify the meaning of a simple word that is not defined within the passage. Recognize the application of instructions given in the text to situations that are also described in the text.
4	Identify important details that are less obvious than those in level 3. Recognize the application of more complex instructions, some of which involve several steps, to describe situations. Recognize cause-effect relationships. Determine the meaning of words that are not defined in the reading material.
5	Identify the paraphrased definition of a technical term or jargon that is defined in text with more details, greater complexity, and broader topics than those in level 4. Recognize the application of technical terms or jargon to stated situations. Recognize the definition of an acronym that is defined in the text. Identify appropriate definition of a word with multiple meanings. Recognize the application of instructions from the text to new situations that are similar to those described in the reading materials. Recognize the application of more complex instructions to described situations, including conditions and procedures with multiple steps.
6	Generalize beyond the stated situation and recognize implied details and the probable rationale behind policies and procedures contained in more complex presentation of information such as regulatory and legal documents as well as more elaborate procedures and concepts. Recognize the application of jargon or technical terms to new situations. Recognize the application of complex instructions to new situations. Recognize, from context, the less common meaning of a word with multiple meanings. Generalize from the text to situations not described in the text. Identify implied details. Explain rationale behind a procedure, policy, or communication. Generalize from the text to a somewhat similar situation.
7	Recognize the definitions of difficult, uncommon jargon or technical terms, based on the context of more difficult text. Figure out the general principles underlying described situations and apply them to situations neither described in, nor completely similar to, those in the text.

Applied Mathematics:

Level	Skills
3	Perform single-step basic operations (addition, subtraction, multiplication, and division) using whole numbers. Change a number from one form to another, using whole numbers, fractions, decimals, and percentages. Add and subtract negative numbers as well as positive numbers.
4	Perform one or two mathematical operations, such as addition, subtraction, or multiplication on several positive or negative numbers. Add commonly known fractions, decimals, or percentages (e.g. 1/2, 0.75, 25%), and three fractions that share a common denominator. Calculate averages, simple ratios, proportions, and rates, using whole numbers and decimals.
5	Perform single step conversions within and between English and non-English systems of measurement. Calculate perimeters and areas of basic shapes. Calculate percentage discounts and markups. Compute the "best deal" using one- and two-step calculations and then comparing costs.
6	Calculate using negative numbers, fractions, ratios, and mixed numbers. Calculate multiple rates and then compare the rates or use them to perform other calculations. Find basic areas and volumes of rectangular solids. Calculate the "best deal" using the results in another problem. Identify and correct errors in calculations.
7	Solve problems involving more than one unknown. Calculate the percentage of change. Calculate multiple areas and volumes of spheres, cylinders, and cones. Setup and manipulate complex ratios and proportions. Determine the best economic value of several alternatives. Find mistakes in multiple-step calculations.

This study or equivalent may be used for pre-employment screening.

Request for Comment

The International Institute of Ammonia Refrigeration (IIAR) and the Refrigerating Engineers & Technicians Association (RETA) have approved the publication of Draft Guideline for Trial Use Ammonia Refrigeration Training Guideline for comment. Comments will be accepted through June 30, 2010. Following the close of the comment period, IIAR and RETA intend to review the comments, make any and all appropriate revisions, and publish the revised draft standard as a formal industry guideline which may include application for approval as an industry guideline to the American National Standards Institute.

Comments should be directed to IIAR Headquarters, ARTG-GDL 1 Comments, 1110 North Glebe Road, Suite 250, Arlington, Virginia 22201, by E-mail to special@iiar.org, or by Fax to 703/312-0065.

Date: ______________________________

Commenter Name: ______________________________

Company: ______________________________

Mailing Address: ______________________________

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Phone: ______________________________

E-mail: ______________________________

Comment:

Please return comments to: IIAR Headquarters, ARTG-GDL 1 Comments,
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