Expertise hub for energy-efficient cooling & heating in European supermarkets
ECO-FRIENDLY OPERATION AND MAINTENANCE OF SUPERMARKETS
SCOPE OF THIS PRESENTATION

• The focus of this presentation is maintenance and monitoring of eco-friendly supermarkets.

• Proper maintenance and monitoring of system components and equipment integrated in refrigeration system, HVAC and lighting.

• Learning about maintenance procedures, monitoring examples, staff training, operator responsibilities and maintenance checklists.

• Case examples of advanced monitoring systems.
1. INTRODUCTION AND TECHNOLOGICAL REQUIREMENTS
2. OPERATION OF SUPERMARKET
3. MONITORING SYSTEMS
4. CASE EXAMPLES OF MONITORING SYSTEMS
5. SERVICE AND MAINTENANCE
6. GOLDEN RULES AND CHECKLISTS
INTRODUCTION AND TECHNOLOGICAL REQUIREMENTS
INTRODUCTION AND TECHNOLOGICAL REQUIREMENTS

• Key factors for achieving a system operating at its peak efficiency

• Significance of each stakeholder in supermarket operation and maintenance:
  • *Supermarket chain or single supermarket owner* –
    Ensuring employee training and expanding their skills and knowledge.
  • *Supermarket responsible staff*
    Operators, who need to have significant knowledge of system operation.
  • *HVAC&R service and maintenance provider*
    Service personnel must possess system and product knowledge in order to approach the equipment and establish proper maintenance routine.
  • *Engineering society/studio*
    Maintenance is effective and less time/cost consuming when it is addressed in the right way from the beginning, i.e. from the planning and design of the building.
  • *Public bodies*
    Legislation should protect the certified technicians and encourage all personnel engaged in equipment maintenance to obtain proper certificate level which will give them knowledge and good working practice in achieving their work in efficient and secure way.
Key person in the organization is the technical staff responsible for the refrigeration system. They should follow up its performance and efficiency, shall:

- Identify possible refrigerant leakage from the refrigeration system.
- Analyze monitored information and interpret them.
- Identify possible problems and instruct contractors to carry out relevant work.
- Be informed and comply with regulations related to food safety regarding temperatures, health and safety.
- Train and educate employees about energy efficiency measures.
Figure 1 Frequency of inspections of HVAC&R systems in Food retail stores. [SuperSmart, 2016].
**Figure 2** Penetration of data monitoring systems in the Food retail sector. [SuperSmart, 2016].
INTRODUCTION AND TECHNOLOGICAL REQUIREMENTS

Technological requirements, equipment and components.

- Equipment and components selection.
- System installations.
- Important considerations when installing major system components.
- Installation examples and tips.
OPERATION OF SUPERMARKETS

One average supermarket store is mix of different systems that have certain operating conditions designed by manufacturers.

Each system should be operated on efficient and functional way under certain operating limits it was designed and installed for.

Operation practices:

• Refrigeration systems
• HVAC systems
• Lighting
Operator responsibilities:

- **Maintenance plan** - Ensuring the frequency and quality of maintenance work

- **Monitoring system** - Using data from monitoring system and investigating the data trends.

- **Temperature sensors** - Regular recalibration of temperature and humidity sensors of the cabinets.

- **HVAC&R system integration** - Considering cost-effective ways to operate and integrate the HVAC&R system.
OPERATION OF SUPERMARKETS

Operator practices:

- **Refrigeration systems** - Refrigeration accounts for about 35 - 50 % of total electrical energy use in the average supermarket [Karampour 2016]. Energy efficient operation of the refrigeration system is hence crucial. Some operation activities will lead to better refrigeration performance.

- **HVAC systems** - Approximately one quarter of all energy used in one supermarket building goes to HVAC [US DOE 2012]. Operation activities regarding the HVAC system impact both customer comfort and building efficiency. Some well-known operation practices can improve the energy performance.

- **Lighting** - Lighting corresponds to approximately 20 % of the supermarket energy demand, hence an energy efficient lighting is crucial for an eco-friendly supermarket [Karampour 2016].

Energy benchmarking

- Supermarket operators should focus on improving the energy performance of their store. This means comparing to certain energy consumption benchmark of the supermarket organization they belong to or to more global benchmarking system.
MONITORING SYSTEMS
Monitoring system can have different features from basic only monitoring data up to more advanced “intelligent” auto adaptive control system. There can be different levels of monitoring:[Carel, 2016]

• Basic monitoring system which features a hardware device and a purpose-developed software program used to monitor a series of parameters and significant values for the operation of the entire system, as well as the operating status. In this case, the status of the system being monitored can only be checked: the software cannot be used to modify or set any of the values.

• Remote management system allows greater optimisation because of possibility of remote access to the monitoring system. From the remote control centre the user can set the system control parameters, such as the operating times, set points and alarm thresholds. This centralised management system can be installed at large distances, simplifying troubleshooting operations.

• Supervision is more complex and evolved control system which can also provide for the system itself to make decisions, when certain situations arise, so as to ensure correct operation, resolve problems and optimise energy consumption. These systems that are based on the supervision concept may be defined as "intelligent", as they are programmed to manage a large number of combinations of data and variations.
The information integrated into monitoring system:

- List of equipment and components
- HVAC&R System schematics
- Temperatures (ambient, display cabinets, cold rooms, etc.)
- Humidity
- Refrigeration system parameters (working fluid temperatures, oil parameters, capacity used, refrigerant operating temperatures, operation mode etc.)
- Refrigerant leak equipment status
- Comparison charts of different operation periods
- Average values
- Different store operation data
- Maintenance schedule plans
- Service performed and outcome
- Safety procedures
- Energy consumption
- Test and inspection intervals
- Alarms and alerts
MONITORING SYSTEMS

• Description of monitoring process.
• Operation of monitoring system.
• Installation and commissioning of monitoring system.
• Generated data from monitoring system.
MONITORING SYSTEMS

Energy management systems – computerized centralized systems

• Monitoring and energy management of each store
• Comparison of energy consumption between stores
• Monitoring and control of parameters for billing of electricity
Examples of different monitoring systems

• Danfoss smart store control system

Figure 3. Controls product overview from Danfoss[Danfoss2016].
Examples of different monitoring systems

The platform includes the following features:

- Alarm Management
- Compressor Status
- Leak Detection
- Refrigerant Levels
- HACCP Reporting
- Global Set point Control
- Password Lockdown
- Energy Information Systems
- Continuous Commissioning Process
- Demand Response
- Remote Assist
- Executive Reporting
Examples of different monitoring systems

- Danfoss smart store control system

**Figure 4.** Example of AK-EM800 alarm list [Danfoss2016].
Examples of different monitoring systems

• Carel monitoring system

Figure 5. Carel retail monitoring and control system overview [Carel 2016].
Examples of different monitoring systems

• Carel monitoring system

Three different levels for monitoring and remote management:

• Local monitoring system
  data analyze functions, energy saving function (floating suction pressure control).

• Advanced enterprise monitoring system
  analyze and compare data by the local supervisors on each system for centralized site management.

• Remote monitoring system
  offers remote control with adjustments updated in real time.
Examples of different monitoring systems

• Eliwell monitoring system

Remote control and supervision systems can integrate multiple components of the plant and functions including refrigeration control, HACCP recordings, energy consumption monitoring and lighting and air conditioning control [Eliwell 2016].

• Compressors rack control, inverter compressor control.

• Remote chilled cabinet controllers.

• Cold room controllers.

• HVAC and lighting control.
MONITORING SYSTEMS

• One of the system advantages is floating condensation based on environmental condition. It means dynamically manage condensation pressure in order to maintain the best temperature differential between condenser and external air, adapting itself to daily and seasonal changes. Power consumption reduction, achievable during low ambient temperature conditions, allows considerable energy saving compared to fixed set point systems. Savings can be achieved up to 25%. [Eliwell, 2016]

Figure 6. Eliwell 24 hours floating set point modulation [Eliwell 2016].
Examples of different monitoring systems

- Green&Cool monitoring system

The Green&Cool control system unit is equipped with a PLC-based control system combined with a touch screen that can display a user-friendly flow diagram.

The different user levels give access to changing set points, resetting alarms, overview of the specific system/equipment parameters, notifying technical staff, viewing trend graphs.
Examples of different monitoring systems

- Green&Cool monitoring system

Figure 7. Overview screen in the monitoring system by Green&Cool [Green&Cool 2015].
Examples of different monitoring systems

• Huurre monitoring system

Figure 8. Typical plant layout in the control system by Huurre [Huurre 2013].
Examples of different monitoring systems

- Huurre monitoring system

Figure 9. Machinery room layout in the control system by Huurre [Huurre 2013].
Examples of different monitoring systems

- Iwmac monitoring system

Figure 10. Supermarket layout [Iwmac 2015].
CASE EXAMPLES OF MONITORING SYSTEMS
Ukraine Convenience store 2015

- Implementing Danfoss adaptive controls and VFD on compressors

Figure 8. Energy consumption old T vs A new adaptive system [Danfoss 2015].
CASE EXAMPLES OF MONITORING SYSTEMS

Intermarché Supermarket in Portugal 2011

• Implementing Eliwell Invensys Controls system integrator.

• System integration of supermarket refrigeration and HVAC, ventilation, lighting and heat recycling for radiant floor heating

Figure 9. Intermarché Supermarket in Portugal [Eliwell 2011].
SERVICE AND MAINTENANCE

05
Service and maintenance are required to keep the building and its energy consuming systems to work on peak performance related to designed capacities and energy consumption.

The benefits are:

- Whole-building energy savings of 5%–20%. [US DOE, 2012]
- Minimal comfort complaints.
- Equipment that operates adequately until the end of its planned useful life, or beyond.
- Design levels of indoor environmental quality.
- Safe working conditions for building operating staff.
System components covered by maintenance:

1) Refrigeration
   • Refrigeration equipment
   • Display cabinets
   • Heat Exchangers

2) Heating, Ventilation and Air Conditioning (HVAC)
   • Boiler/burner heating source
   • Chiller/heat pump for cooling/heating
   • Air handling unit – AHU
   • Air ducts and grilles
   • Indoor units (water terminals, DX units)

3) Lighting

4) Building Envelope
Refrigeration - *Refrigeration equipment*

**Table 5.1. Possible causes for refrigerant leaks.[GTZ Proklima 2008]**

<table>
<thead>
<tr>
<th>Possible cause</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration</td>
<td>Vibration can lead to material failure, misalignment of seals, loosening of bolts to flange connections, etc.</td>
</tr>
<tr>
<td>Damage due to frictional wear</td>
<td>There are many cases of frictional wear causing material failure, and they vary from poorly-fixed pipework to malfunctioning shaft seals.</td>
</tr>
<tr>
<td>Not proper material used</td>
<td>There are certain cases where not suitable material is used and that will eventually lead to leaks. Different examples exist such as using flexible connection hoses which are known to have a potential risk for leaking, or using materials that cannot withstand the high pressure of the system or pressure/temperature difference changes that are occurring in the system.</td>
</tr>
<tr>
<td>Poor quality control</td>
<td>Important factor during the production process itself is the quality control of both material components and assembly process having in mind the excessive temperature/pressure difference that the material needs to comply with.</td>
</tr>
<tr>
<td>Poor connections</td>
<td>There are different types of joints, brazed, flared or even valves with no caps, and all of these points are potential places where refrigerant can leak out of the system.</td>
</tr>
<tr>
<td>Corrosion</td>
<td>Corrosion can be caused by different chemicals in different weather conditions that will eventually decay the used material.</td>
</tr>
<tr>
<td>Accidental damage</td>
<td>Accidents should be prevented right from the transport and during installation, operation and service. Packaging should prevent mechanical damage during transport and the system should be designed, installed and located in a way to prevent external mechanical damages as much as possible.</td>
</tr>
</tbody>
</table>
SERVICE AND MAINTENANCE

Refrigeration - *Display cabinets*

- Proper door operation,
- Door gaskets cleanness,
- Inspection of cabinet fans,
- Proper cabinet product loading (no products on return grid),
- Proper cabinet location in the store.

Refrigeration – *Heat Exchangers*

- Regular inspection of cleanness of HE.

*Figure 10. Supermarket cabinets*

*Figure 11. Example of dirt/clean heat exchanger*
Heating, Ventilation and Air Conditioning (HVAC) – **Boiler/burner heating source**

- Checked for fuel leaks regularly.
- Inspection of flame sensor and fuel line for any possible clogging or reduced fuel flow.
- Burner proper operation.

Heating, Ventilation and Air Conditioning (HVAC) – **Chiller/heat pump for cooling/heating**

- Same maintenance procedure that counts for refrigeration unit applies to chiller/heat pump.
Heating, Ventilation and Air Conditioning (HVAC) – *Air handling unit - AHU*

- Cleaning of air filters regularly.
- Proper operation of moving parts (dampers, economizers etc.)
- Inspection of air ducts non obstructive air flow.
- Insulation inspection preventing heat loss.

Heating, Ventilation and Air Conditioning (HVAC) – *Indoor units (water terminals, DX units)*

- Cleaning of air filters regularly.
- Indoor fans inspection for proper air flow.
Lighting
- The lighting efficiency can also be reduced due to dirt accumulation on the lenses, bulbs or reflectors.
- The use of LED lighting should be considered whenever possible.
- Proper operation of lighting controls.

Building Envelope
- Maintaining the building thermal performance – thermal insulation inspection.
- Inspection of wear of seals from doors and windows.
GOLDEN RULES AND CHECKLISTS

07
### Table 7.1. Checklist for system component maintenance [Supermarket BP 2012]

<table>
<thead>
<tr>
<th>Description</th>
<th>Daily</th>
<th>Weekly</th>
<th>Monthly</th>
<th>Yearly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigeration - Maintenance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cabinets and cold rooms operation (superheat control, cold air distribution, defrost etc.)</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Check for abnormal noise, vibration or low performance of compressors/motors.</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspect refrigeration coils and establish regularly cleaning routine.</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check and replace worn and/or leaky door seals.</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control proper operation and time efficiency of defrost system management and moisture sensors to ensure optimal performance.</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Clean fans and inspect for wear and tear of fan belts.</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Clean and disinfect condensate drain pans.</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>If local controls are present, check if non authorized temperature adjustment is locked.</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>If refrigerant detectors are placed, inspect regular operation according to manufacturer instruction.</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Control the work performance of maintenance contractor if existing.</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>
Table 7.1. Checklist for system component maintenance [Supermarket BP 2012]

<table>
<thead>
<tr>
<th>Heating, Ventilation and Air Conditioning (HVAC) - Maintenance</th>
<th>Daily</th>
<th>Weekly</th>
<th>Monthly</th>
<th>Yearly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean/replace the air filters on fan coils (water terminals), DX indoor units and AHU's.</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secure non obstructive air flow to and from FCU or DX units.</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check work condition on air curtains in entry areas.</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspect insulation on all piping and ductwork of the HVAC system.</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Inspect ductwork connections and seal if there is air leakage.</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Check for abnormal noise, vibration or low performance of compressors/motors.</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspect condenser coils and establish regularly cleaning routine.</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean and disinfect condensate drain pans.</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Check if the control adjustment is locked on HVAC temperatures for non-authorized usage.</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Control proper combustion process if boiler/burner is used for heating</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>If fossil fuels are used in burner, test operation of carbon monoxide (CO) detectors.</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>If water heaters are used, proper operation of electrical heater and set point control should be checked</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Control the work performance of maintenance contract contractor if existing.</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>
### Table 7.1. Checklist for system component maintenance [Supermarket BP 2012]

<table>
<thead>
<tr>
<th>Lighting - Maintenance</th>
<th>Daily</th>
<th>Weekly</th>
<th>Monthly</th>
<th>Yearly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean lamps to achieve maximum illumination.</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Check for broken lamps and replace with energy efficient lighting.</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test task lamping and motion sensor if present for proper timing operation.</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Building Envelope - Maintenance</th>
<th>Daily</th>
<th>Weekly</th>
<th>Monthly</th>
<th>Yearly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make visual inspection on the building insulation.</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Check window seals and possible window cracks.</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Clean windows and roof-lights to maximise daylight where possible</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspect for possible draft areas in the building.</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>