

The FrostByte dataset

Introduction

It is with great pleasure that we announce the release of the "FrostByte" dataset. The dataset was collected during research on fault detection and diagnosis (FDD) approaches and their transferability to heterogeneous systems of industrial refrigeration systems at the Technical University of Applied Sciences Wildau. The data collection took place between 2018 and 2019 and is intended to supplement the ASHRAE 1043-RP dataset (Comstock & Braun, 1999), which has been the only publicly available data source in this area to date. For comparison purposes, the method of data collection was chosen similarly, whereby this dataset collection was carried out using a ~ 100 kW refrigeration capacity ammonia system with plate heat exchangers.

The dataset contains steady-state data equally sampled from five classes:

1. Normal (fault-free operating condition)
2. Reduced Condenser Water Flow
3. Reduced Evaporator Water Flow
4. Non-Condensable Gases
5. Refrigeration Leak

Each class was investigated under changing operational conditions and varying fault severity levels (SL).

We are releasing this dataset with the aim of providing researchers an opportunity to enhance and validate their models using additional data. Recognizing that data scarcity is a major challenge in this field, our goal is to contribute to overcoming this hurdle and advancing research.

The following provides an overview of the dataset and its origin. For more details, the reader is referred to

(van de Sand, 2021)

<https://art.torvergata.it/handle/2108/323763>

or

(van de Sand et al., 2021)

<https://www.sciencedirect.com/science/article/pii/S0967066121000927>

Test Rig

The chiller, shown in Figure 1, applied R-717 (ammonia) refrigerant and was designed to simulate specific faults. It had a screw compressor driven by a 35 kW three-phase synchronous motor and controlled by a frequency-controlled drive. Plate heat exchangers were used for both the condenser and the evaporator, the latter being flooded. A horizontal

vapor-liquid separator prevented the compressor from drawing in liquid refrigerant and causing potential damage.

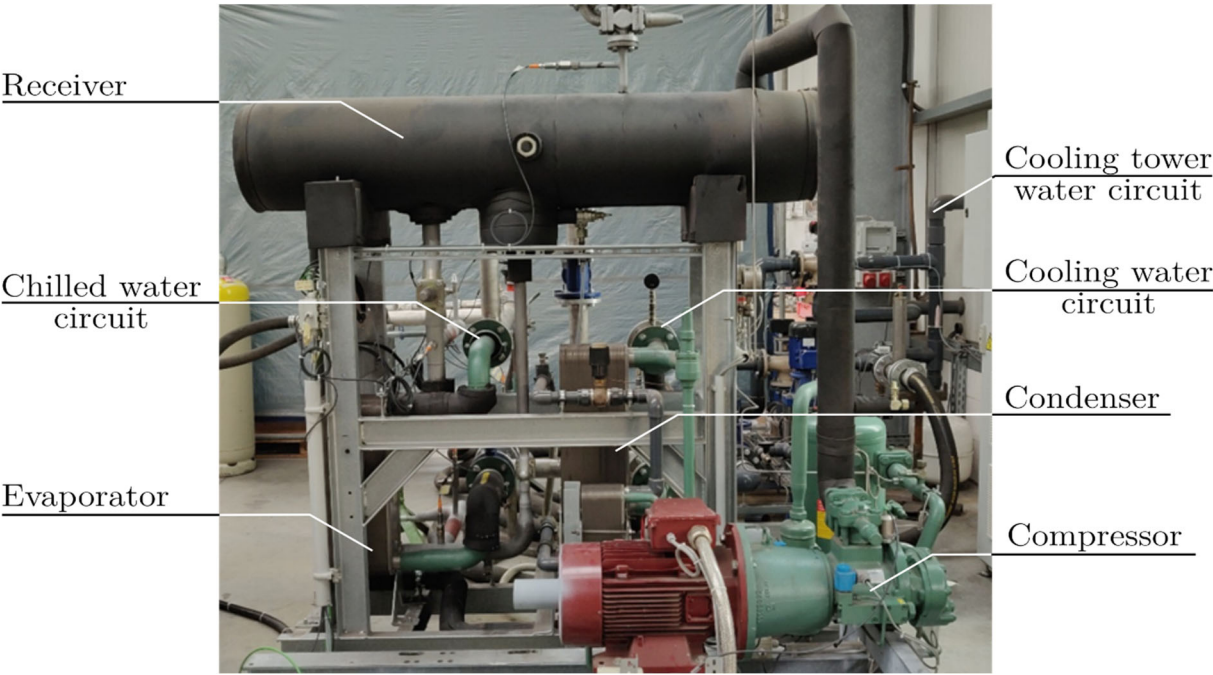


Figure 1 Test rig

The system also had two three-way valves that controlled the water-glycol mass flows and adjusted the inlet temperatures to the condenser and evaporator. The excess heat was discharged to the outside via a cooling tower, which made it possible to simulate different ambient temperatures. A simplified overview is provided in Figure 2.

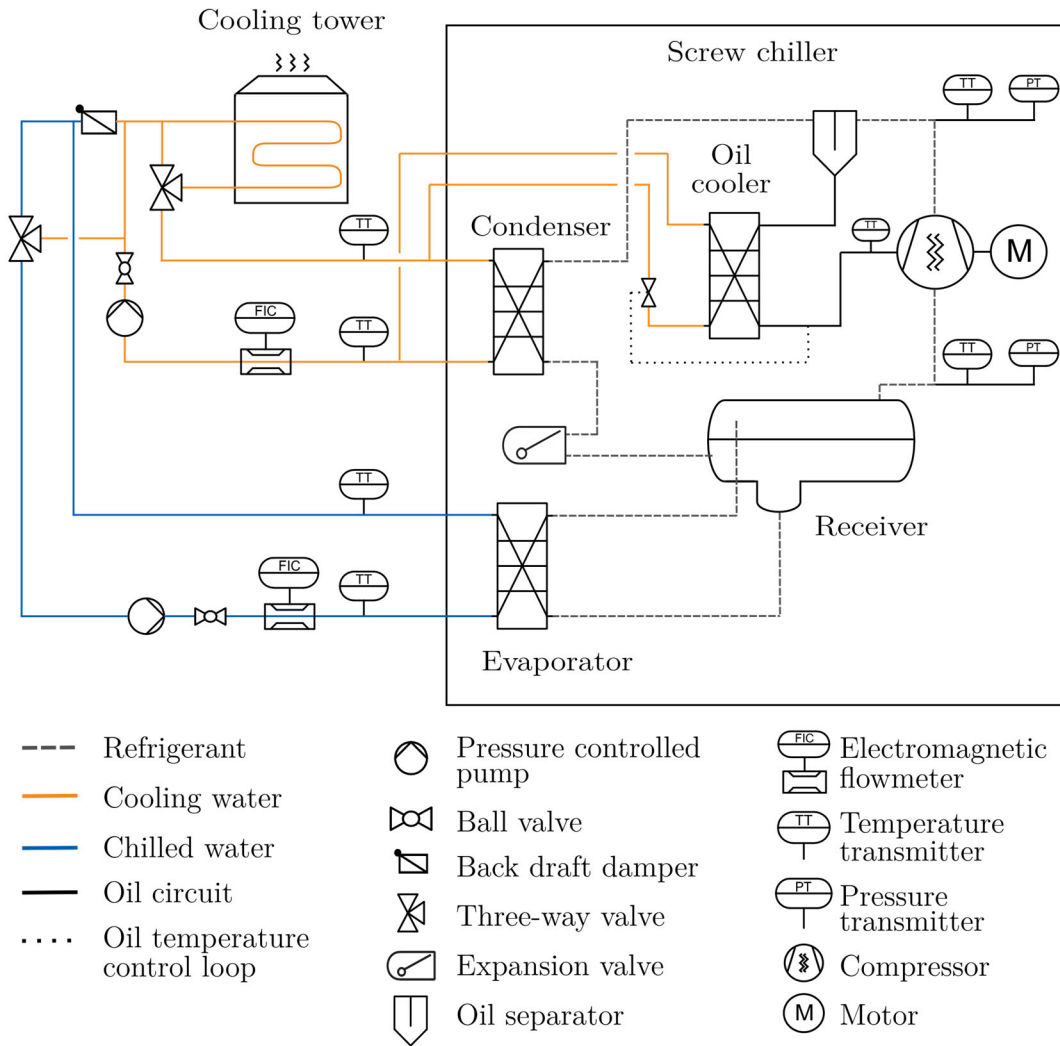


Figure 2 Simplified test rig piping diagram

Data Collection

After conducting several benchmark tests to ensure data reproducibility, faults were introduced at progressively increasing severity levels, as shown in Figure 3.

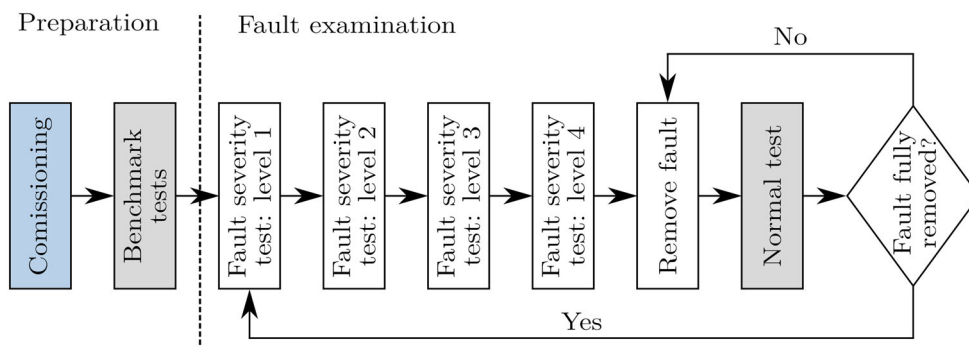


Figure 3 Fault examination

The chosen approach was similar to that of the ASHRAE 1043-RP project, where 27 operational states were defined. Each operational state was met only after meeting a steady-state criterion for at least 5 min. Moreover, the test procedure was consistently maintained across all test cases, as shown in Figure 4 (see Table 2 below for variable declaration)

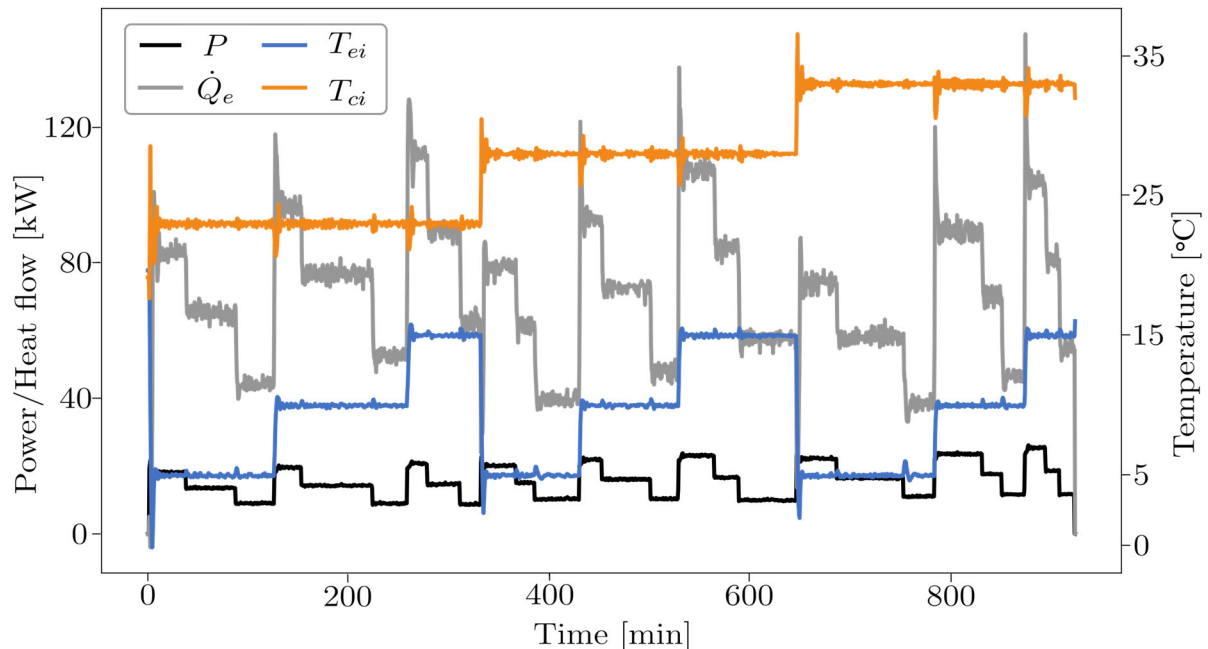


Figure 4 Example of a test procedure

Fault Classes

“FrostByte” features a total number of five classes, including four fault classes and one fault-free class labelled as NORMAL. Data were specifically collected from the chiller's steady-state operation condition. These steady-states were identified using the algorithm proposed by Beghi et al. (2016).

Each of the fault classes was investigated across various severity levels, ranging from SL1, which denotes the lowest severity level, to SL4, indicating the highest level of severity. SL0 is only associated with the normal operating conditions of the system. However, there were exceptions in this procedure:

Refrigerant Leak: During the investigation of this fault, we detected significant deviations from normal operating conditions, particularly at higher severity levels. These deviations were often followed by system failures, preventing the achievement of all operating conditions. Consequently, the data set includes only two levels of severity.

Non-condensable Gases (Nitrogen): The injection of nitrogen, as a non-condensable gas, into the system resulted in elevated pressures, especially at higher severity levels. Consequently, not all operational conditions could be reached, sometimes leading to emergency shutdowns of the system.

For each class, 1000 samples were randomly sampled, leading to a total number of 5000 samples in the dataset. The class distribution, including the distributions across all SLs, is shown in Figure 5.

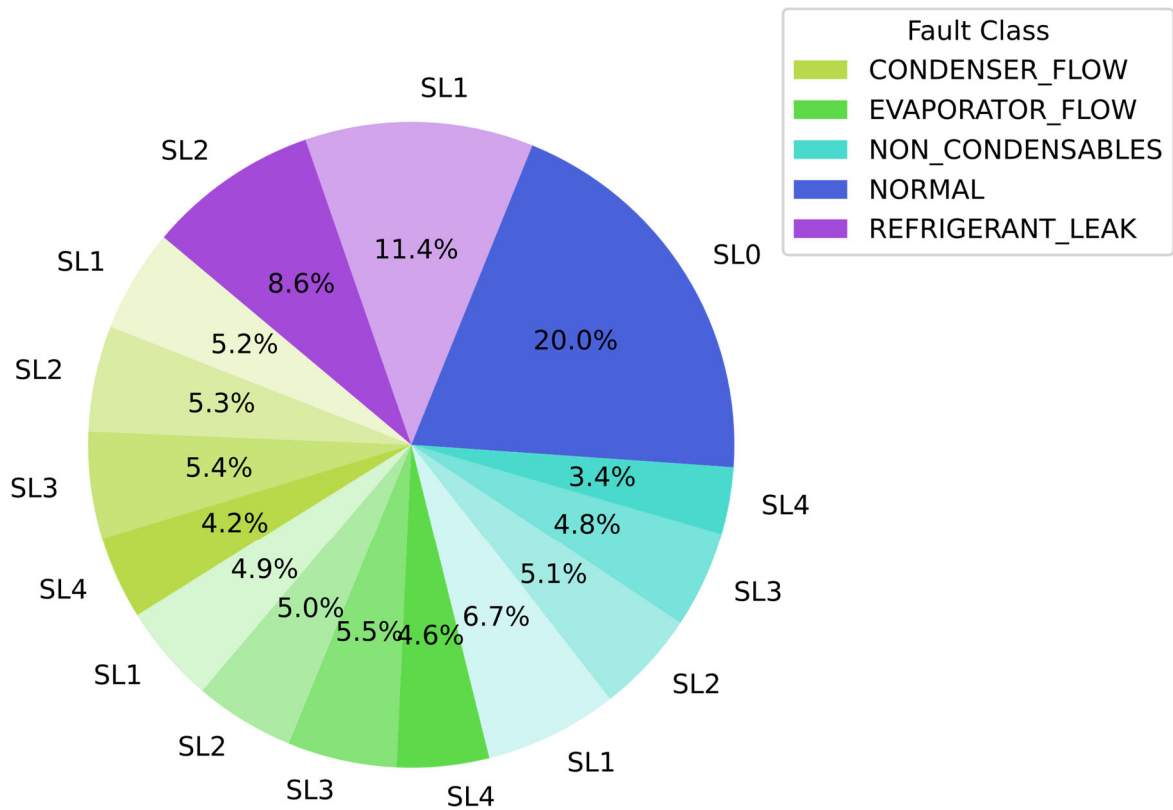


Figure 5 Class distribution

Features

In total, 21 features of both measured and computed features were selected, as shown in Table 1. Note that, for comparison reasons, the variable names were chosen similar to the ASHRAE dataset.

Table 1 Selected Features

Symbol	Variable Name	Designation	Unit
T_{ci}	TCl	Water temperature at condenser inlet	°C
T_{co}	TCO	Water temperature at condenser outlet	°C
T_{ei}	TEI	Water temperature at evaporator inlet	°C
T_{eo}	TEO	Water temperature at evaporator outlet	°C
T_{oil}	TO_feed	Oil feeding temperature	°C
T_{suc}	T_suc	Refrigerant suction temperature	°C
T_{dis}	TR_dis	Refrigerant discharge temperature	°C
p_{rc}	PRC	Refrigerant pressure at compressor outlet	bar
p_{re}	PRE	Refrigerant pressure at compressor outlet	bar
P	kW	Instantaneous motor power (compressor)	kW
\dot{Q}_C	Cond_Capacity	Condenser heat flow	kW
\dot{Q}_E	Evap_Capacity	Evaporator heat flow	kW
T_{re}	TRE	Refrigerant evaporation temperature	°C

T_{rc}	TRC	Refrigerant condensing temperature	°C
ΔT_{ea}	TEA	Evaporator approach temperature	K
ΔT_{ca}	TCA	Condenser approach temperature	K
ΔT_E	TWED	Evaporator water-glycol temperature difference	K
ΔT_C	TWCD	Condenser water-glycol temperature difference	K
$\Delta T_{sh,dis}$	Tsh_dis	Superheat temperature at compressor discharge	K
$\Delta T_{sh,suc}$	Tsh_suc	Superheat temperature at compressor suction line	K
ϵ	COP	Coefficient of performance	

Table 2 Selected Features

Remarks

The "FrostByte" dataset is tailored for developing data-driven models in FDD, particularly focusing on transfer learning/domain adaptation. It's not designed for in-depth chiller system analysis but rather for practical research. Users should be aware that while the dataset provides precise data conducive to FDD applications, its accuracy in terms of measurements might not suit all research needs. Especially some computed values should be interpreted with care. However, as highlighted by Comstock & Braun (1999), in FDD, data precision is more important than absolute measurement accuracy.

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Licence

The dataset is released under CC-BY-NC (non-commercial use).

Citation

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Authors

Ron van de Sand

In his research, Dr. Ron van de Sand focused primarily on data-driven approaches for predictive maintenance and the application of artificial intelligence in industrial processes. From 2020 to 2024, he was deputy research group leader of the IC3 group at the University of Applied Sciences Wildau. As part of his dissertation, this dataset was collected within one year between 2018 and 2019.

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Professor Reiff-Stephan, employed at Faculty of Engineering and Natural Sciences and directs the Institute of Cyber-physical Production Systems (CPPS), TH Wildau, Germany. An active researcher in the areas of usability of CPS control in production processes within the framework of a holistic automation approach as well as acceptance and education strategies in CPPS.

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