HIT

Challenges of environmental testing

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MIKES METROLOGY

Contents

Introduction:
Dialogue between VTT MIKES and Huawei

- Several discussions before and during HIT:
  - Information about humidity metrology related advancements, services and projects at VTT MIKES and other European NMIs
  - Information about humidity related measurement needs and challenges at Huawei
  - Collaboration:
    - Identification of potential topics
    - Monitoring on-going collaboration
- Focus: challenges in reliability testing

Humidity Measurement Challenges During Reliability Testing

November 2017

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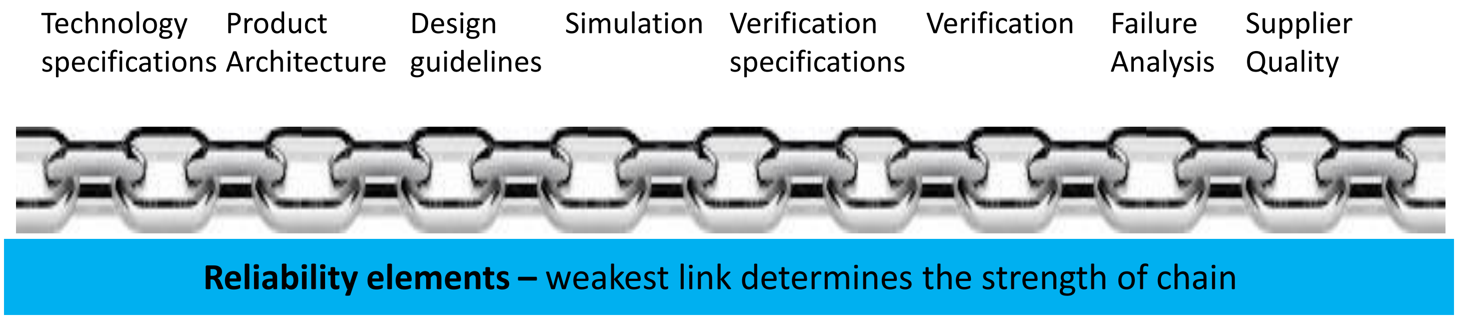
1. Reliability Competence Center Mission

RCC Finland focuses on reliability by improving FFR and user experience in Huawei Devices. Build device reliability design system, be Best Reliable product in Android platform.



2. HAST Test - Introduction

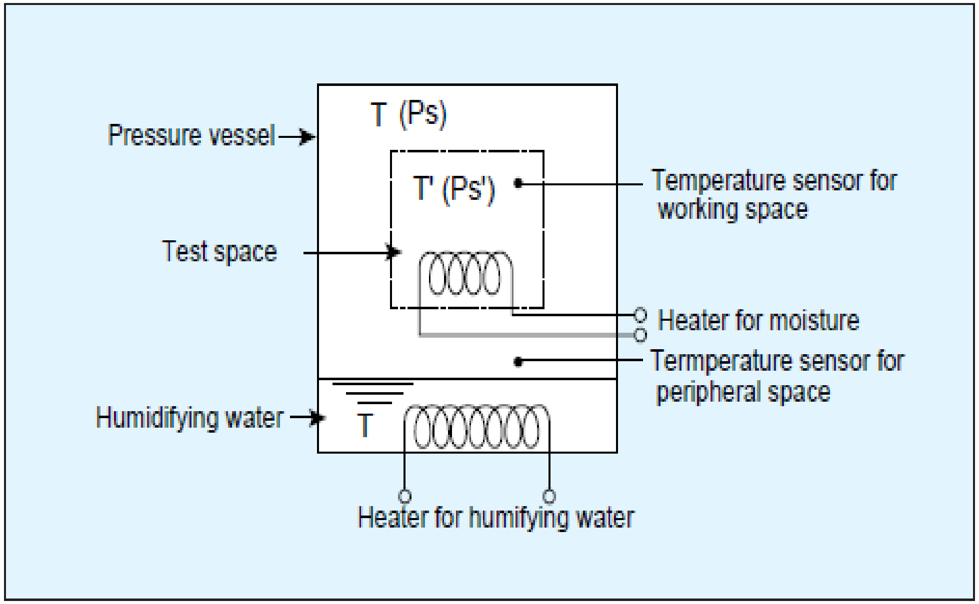
- HAST (Highly Accelerated Stress Test) or PCT (Pressure Cooker Test) has been used for decades on R & D verification for determine the resistance of the materials, components etc. against humidity at highly accelerated test condition.

- Highly accelerated test condition is achieved by using hermetically sealed chamber (picture 1) which can control temperature, pressure and “relative humidity” of the chamber. Ideal principle for operation is that dry air (partial pressure Pa) is removed from the chamber which left chamber containing only water vapor without air. By control of the pressure and chamber air temperature amount of water vapor can exceed the amount of water vapor occurred on natural conditions -> accelerated condition.

- “Relative humidity” inside the chamber is:

$$\psi' = \frac{\text{Peripheral space saturated water vapor pressure (Ps)}}{\text{Saturated water vapor pressure at the temperature in the partial area (Ps')}} \times 100\ (\%RH)$$

- Typical test conditions based on IEC, JIS, JEDEC standards vary from 110˚C to 130 ˚C . Unsaturated 85 % “RH” to 100 % “RH” saturated.



Picture 1. Principle of HAST test chamber

Source:
(https://www.test-navi.com) ESPEC Technology Report Nr. 5

2.1 Humidity Measurement On HAST Chamber – Problem Statement

- To be able to determine “relative humidity” Ps and Ps’ need to be known. Peripheral space pressure Ps is measured directly by using the pressure gauge. However, **partial area pressure Ps’ is not measured directly**. Ps’ is determined by measuring the temperature on partial area and by using JSME (1968) steam tables (picture 2) for conversion.

- Ideal assumption is that inside the chamber only water vapor is presented and thus total pressure P = Pw. **In reality amount/effect of the partial pressure is unknown which cause error** when “relative humidity” is defined by using the JSME table and pressure gauge reading.

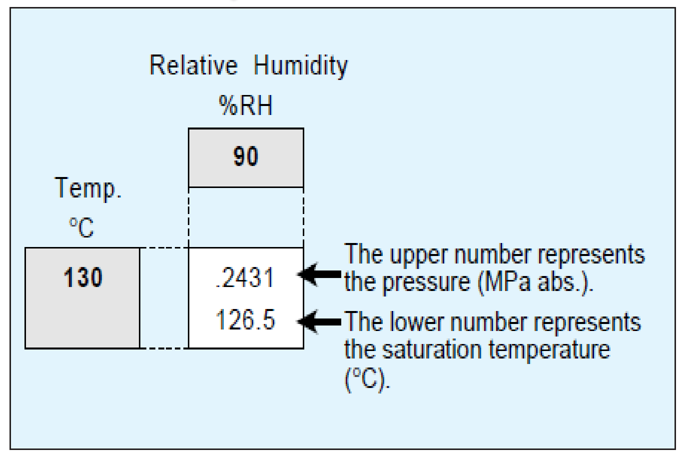
- **Using external measurement equipment inside the chamber is difficult due to the fact that typically chamber has only electrical via “hole”.** Resistance and capacitance of chamber terminals may/will effect to the accuracy of the measurement equipment.

- High temperature > 100˚C and high amount of water vapor limit the use of certain measurement methods.

- **No standard calibration method available.**

- User point of view no understanding of deviation and variation on pressure and “relative humidity” setting values compared to the real (reference) values between different equipment models and during longer usage time period.

Pressure . MPa abs . / Saturation Temperature (°C)												
Temp. °C	Relative Humidity %RH											Temp. °C
	100	95	90	85	80	75	70	65	60	55	50	
129	.2621 129.0	.2490 127.3	.2359 125.5	.2228 123.7	.2097 121.7	.1966 119.7	.1835 117.5	.1704 115.2	.1573 112.8	.1442 110.2	.1311 107.4	**129**
130	.2701 130.0	.2566 128.3	.2431 126.5	.2296 124.7	.2161 122.7	.2026 120.6	.1891 118.5	.1756 116.2	.1621 113.7	.1486 111.1	.1351 108.3	**130**
131	.2783 131.0	.2644 129.3	[illegible]	.2366 125.6	.2227 123.7	.2087 121.6	.1948 119.4	.1809 117.1	.1670 114.6	.1531 112.0	.1392 109.1	**131**



Picture 2. Example of JSME steam table used on calculations.

Source:
(https://www.test-navi.com) ESPEC Technology Report Nr. 5

3. Humidity Measurement During Cyclic Humidity Test - Introduction

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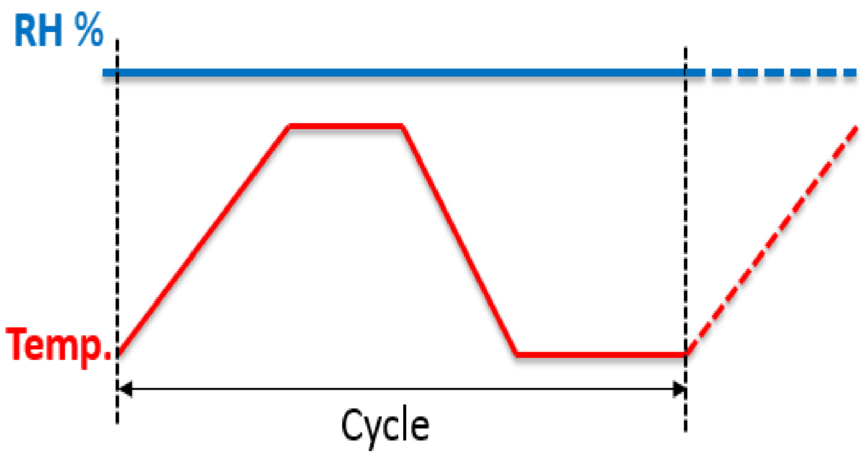
- Cyclic humidity test is the most common humidity related test used on different industrial areas. **Typically relative humidity is constant and temperature will be changed after constant period providing cyclic absolute humidity** (picture 3). Some test standards specify to change temperature and humidity at the same time.

- Test condition at most common standards on electronic area (IEC, MIL, ISO, IPC):

  - Temperature ramp up change rate from ~0,15 ˚C/min to 1,5 ˚C/min.
  - Temperature ramp down change rate < ~3.0 ˚C/min.
  - Temperature range from 10˚C to 65˚C. On special cases up to 85 ˚C.
  - Humidity range from 30% RH to 97 % RH.
  - Test profile tolerances: For humidity typically ±2…4 % RH, for temperature typically ± 1…5 K. Depends if low or high temperature / humidity.



Picture 3: Example of cyclic damp heat test profile.

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3.1 Humidity Measurement During Cyclic Humidity Test – Problem Statement

Occasionally temperature and humidity measurement need to be performed by using external measurement unit during cyclic damp heat test.

Main reasons are:

1. Microclimate near the test samples.

2. **Validation of different chamber models or chambers from different suppliers.**

3. In some cases tolerances on test standards are more strict than equipment tolerances. Equipment might still fulfill the requirement on the standard but there is no way to proof it without additional measurement.

Weiss Climatic Chamber
Source: Weiss WK3 datasheet. http://weiss-uk.com

3.1 Humidity Measurement During Cyclic Humidity Test – Problem Statement

4. Temperature and humidity calibration for climatic chamber specified on common standards (IEC, JTM, JJF) focus on calibration performed at constant temperature and humidity. **No standard method available for calibration performed at changing condition.**

5. Performance and accuracy information specified on the climatic chamber manufacturer data sheet is **defined for constant condition.**

6. **Field calibration for the climatic chamber are typically performed only at few temperature and humidity points**. Main reason for this is mainly time and cost. Due to this, from calibration results linearity can't be typically defined for the whole test range.

7. Chamber performance with and without load. Typically loading of chamber will vary. Addition to the heat load this also effect to the air circulation inside the chamber.

Cold-Heat	Object of calibration		Reference		Measuringuncertainity
Calibration variable	Set points	Actual values	Correct value	Deviation	Total
Temperature:	23,00	23,00	22,94	0,06	0,2(K)
Temperature:	80,00	80,00	79,19	0,81	0,2(K)
Acceptable deviation in space (+/-)			2K		

Climate	Object of calibration		Reference		Measuringuncertainity
Calibration variable	Setpoints	Actual values	Correct value	Deviation	Total
Temperature:	23,00	23,00	23,24	-0,24	0,2(K)
Humidity:	50,00	50,00	48,73	1,27	1,5(%rH)
Temperature:	95,00	95,00	95,07	-0,07	0,2(K)
Humidity:	50,00	50,00	50,87	-0,87	1,5(%rH)
Acceptable deviation in space (+/-)			3%rH		

Example of climatic chamber field calibration results.

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3.1 Humidity Measurement During Cyclic Humidity Test – Problem Statement

8. When using external measurement unit (traceable calibrated) accuracy and uncertainty of the measurement is better known than when using the equipment own sensor.

   - Uncertainty, data processing methods, calculations (if used) etc. can be taken account on final measurement result.

   - Knowledge of the chamber own sensor performance is mainly based on the information presented on the climatic chamber data sheet. **Most of the key information's are missing including example the algorithm's used for measurement which typically effect to the measurement response time.**

Temperature range	+10 to+95 °C
Dew point range	-3 to +94 °C
Humidity range	10 to 98 %RH
Temperature deviation in time in centre of working space	± 0.1K to ± 0.3K
Temperature homogeneity in space based on setpoint, range > 20 % RH	± 0.5K to ± 1K
Humidity deviation in time in centre of working space	± 1% to ± 3% RH

Example of climatic chamber specifications
Source: Weiss WK3 Installation and operation manual.

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3.2 Humidity Measurement During Cyclic Humidity Test – Current solution

With current technology measurement during the cyclic damp heat can be done by using chilled dew point mirror.

+ Measurement accuracy and uncertainty is known on whole measurement range.

+ Accuracy and reproducibility is better than in the chamber own measurement unit.

- Drawback is that calibration of the equipment is performed at steady-state condition. Due to this possible measurement uncertainty from response time of the equipment need to be defined by performing additional unofficial experiment.

- Cost of the equipment can be bottleneck on some cases.

MBW dew point chilled mirror
Source: MBW 573 datasheet

4. Summary

- Presentation shows that on HAST testing area there is clear need for measurement solution at high temperature (> 100˚C) and high humidity condition at pressurized environment which can be used for equipment validation.

- Basic requirement for the measurement equipment used on measurements at non static climatic conditions (e.g. cyclic damp heat test) is that equipment accuracy and measurement uncertainty is known also at non static state. Development of new calibration method would give better understanding of real accuracy and would improve the knowledge of measurements done at non static conditions.

Metrology developments addressing these challenges

- HIT project:
  - Primary reference for humidity at high temperatures (> 100 °C)
  - Calibration methods for relative humidity at high temperatures (> 100 °C)
  - Uncertainty estimation methods for relative humidity at high temperatures
  - Uncertainty estimation methods for relative humidity in non-static conditions
  - Humidity calibration method for non-static conditions
- Global metrology organisation CIPM/CCT
  - Improved definition for relative humidity
  - Harmonised terms and definitions for humidity
- Future:
  - Specific problems related to HAST
  - Cycling test specific uncertainty estimation methods and improved proficiency test procedures

Summary

- Dialogue between VTT MIKES and Huawei about humidity measurements in reliability testing
- HAST testing has major challenges in humidity control and determination
- Non-static conditions in cyclic humidity tests: what is the reliability of humidity measurements?
- HIT address many of presented challenges but follow-on work will be needed

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Thank you

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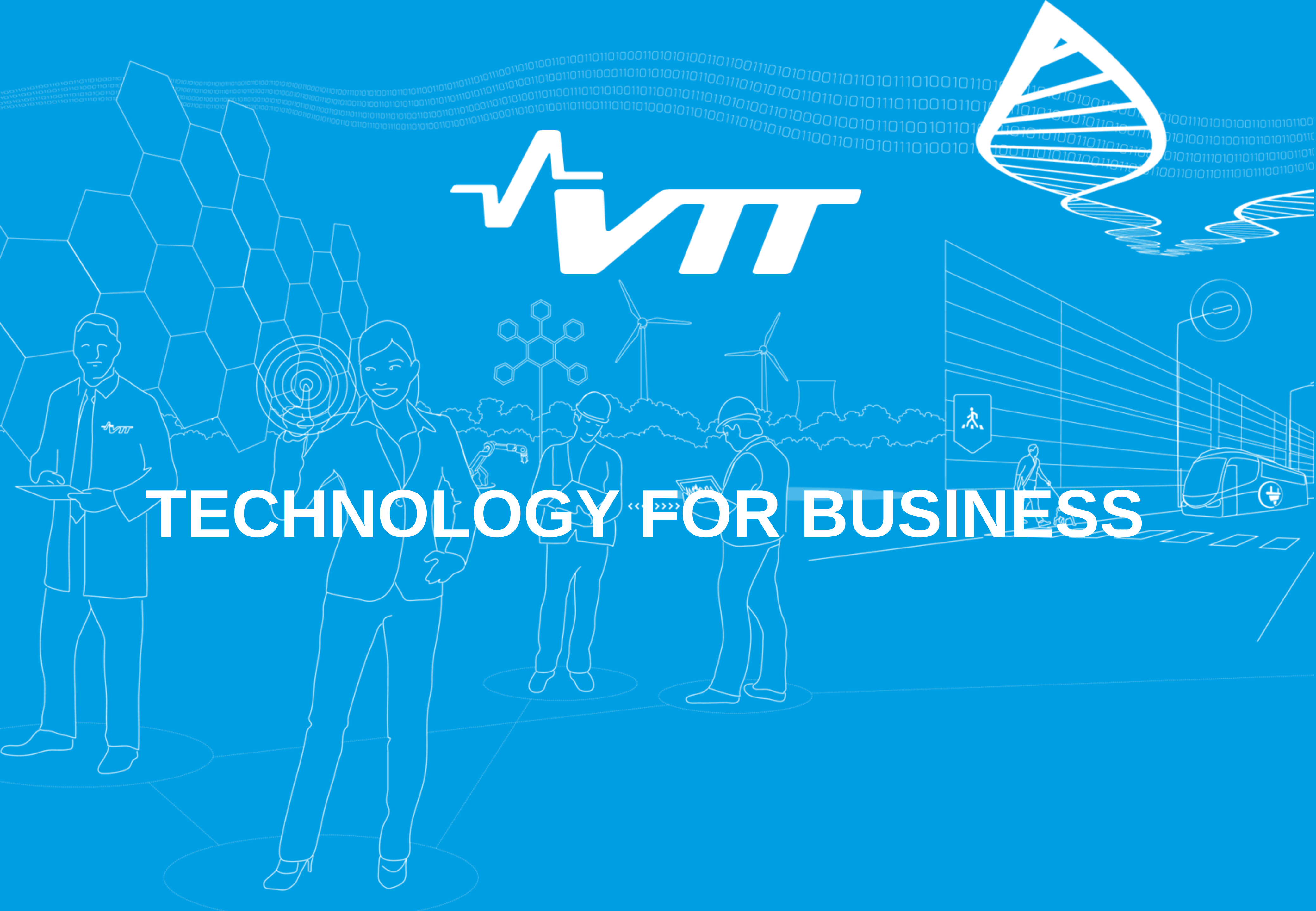
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