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CHANGE OF SPEED OF COMFORT PARAMETERS IN THE ARMORED COMBAT VEHICLES OF THE SERBIAN ARMY DUE TO ENVIRONMENTAL CONDITIONS

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Abstract: *This scientific paper refers to the conditions of the working environment of the crew members of the combat armored vehicle from the aspect of climate comfort and from the aspect of speed of the response of sensors (transducers).*

Keywords: *working environment, climate comfort, speed of the response of sensors.*

1. INTRODUCTION

The heating system was tested in real field conditions and warehouse conditions. The parameter that is considered the test standard is the temperature is in the storage conditions of the armored combat vehicle (storage space temperature), and the speed of reaching the heating temperature of the crew cabin in storage conditions and in conditions without storage capacity is measured, as well as speed of the response of sensors (transducers).

This will be shown through a comparison of the achieved results of the heating and air conditioning system in real working conditions with the functional capability of the heating and air conditioning system in storage conditions on the armored combat vehicles of the Serbian Armed Forces. The system's response speed will show us the accuracy of the measured data in real time, that is, the testimony of the measured measurement results.

The environmental conditions that must be met, according to ISO 7730:2005 [1] and ANSI/ASHRAE 55-2020 [2] standards, are as follows: ($-0.5 \leq PMV \leq +0.5$, $PPD \leq 10\%$, $\Delta t \leq 5°S$, $\tau \leq 60$ min), i.e. according to Fanger's criteria [3] for the termal comfort of the working environment.

Measurements were made with calibrated measuring equipment, thermal comfort meter B&K 1212 and sensor MM0023 at ambient temperature and Tachymeter PeakTech type 5180.

The measurement was carried out at nine measuring points.

2. EXPERIMENTAL SETUP AND METHODOLOGY

The development of armored combat vehicles was realized through the development and integration of newly developed and improved subsystems. With the modernization of this armored fighting vehicle, the vehicle itself has been modernized with an air conditioning and heating system. This brought with it various challenges, both functional and technical, as well as the problem of how to meet the requirements of the ISO 7730:2005 and ANSI/ASHRAE 55-2020 standards.

By installing and integrating air conditioning and heating systems, the working environment of servers is improved.

The air conditioning system should be provided in the administrative and fighting compartment, while the heating system should provide heating in the same space, i.e. the administrative and combat area.

The difference that is particularly emphasized here between these two systems is that the air conditioning system is active only during engine operation, and the heating system has the possibility of overheating when the engine is not running with special systems installed just for that purpose.

The test was carried out at two locations. One location is a military training ground, and the other location is a storage area.

The examination was carried out in the summer period.

It's an all-male crew in an armored fighting vehicle.

There is nine measurement points in the vehicle. The

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sketch is given in Figure 1. The length of the measurement response on the sensors (transducers) is ten seconds on three measurement channels.

The first measurement was within the storage space at an average outside temperature of 40 ºC. At the ambient temperature in which the armored combat vehicle is located, the air conditioning system should achieve and maintain the temperature inside the working area of the armored combat vehicle in the range from 16 ºC to 28 ºC.

The temperature range is shown in Table 1, in which the bolded values are within the range of thermal comfort for crew members.

The second measurement was within conditions of the working environment space at an average outside temperature of 40 ºC. At the ambient temperature in which the armored combat vehicle is located, the air conditioning system should achieve and maintain the temperature inside the working area of the armored combat vehicle in the range from 16 ºC to 28 ºC.

The temperature range is shown in Table 2, in which the bolded values are within the range of thermal comfort for crew members.

Table 1. Temperature range within the storage space in °C

time	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
11.35	41.9	39.2	42.5	40.2	41.5	40.8	42.3	39.5	40.3	43.6
11.45	34.9	38.2	39.1	32.2	36.6	34.6	35.8	32.9	35.8	42.3
11.55	33.1	37	37.2	29.9	34.6	32.5	33.1	30.6	33.6	41.7
12.05	32.1	36.4	35.5	28.1	33.2	30.9	31.6	29.1	32.1	
12.15	31.5	36.1	34.5	**27.3**	32.3	30.3	30.6	28.1	31.1	
12.25	31	35.6	33.6	**26.8**	31.7	29.5	29.6	**27.4**	30.3	
12.35	30.7	35.7	33.5	**26.1**	30.9	28.9	28.9	**26.7**	29.6	
12.45	30.6	35.7	32.3	**25.5**	30.2	28.5	28.2	**26.3**	29.1	
12.55	30.4	35.6	32.1	**25.3**	29.6	**27.9**	**27.7**	**25.8**	28.5	
13.05	30.2	35.5	31.5	**25**	29.4	**27.7**	**27.4**	**25.4**	28.3	
13.15	30.1	35.3	31	**24.8**	29	**27.2**	**26.7**	**25.2**	28.1	
13.25	32.1	36.4	35.5	28.1	33.2	30.9	31.6	29.1	32.1	

Monitoring and control systems have also been modernized in the form of various sensors that must provide:

- power supply of armored combat vehicles,

- determination of necessary and sufficient elements within armored combat vehicles,

- calculation of necessary and sufficient elements within armored combat vehicles,

- manual input within armored combat vehicles,

- information about an error within armored combat vehicles,

- supervision and management,

- reception and accurate detection of thermocouples,

- sending signals to activate electromagnetic valves.

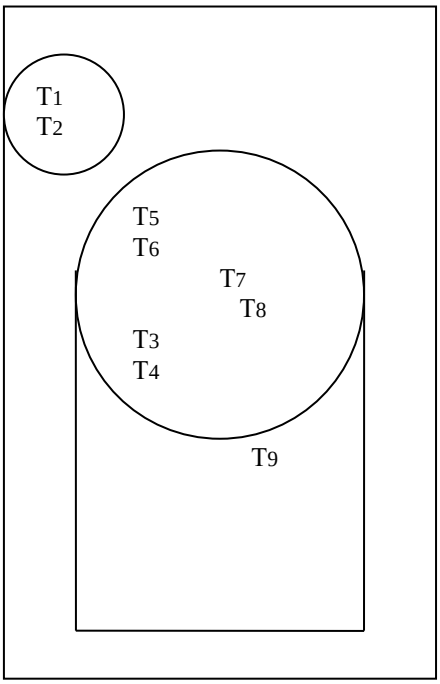

Figure 1. The positions of the measuring points

The characteristics of the air conditioning and heating system itself are as follows:

- Cooling system capacity.....14.2 kW

- Capacity of the heating system.....25.3 kW

- Coolant.....freon R 134 a

- Air flow.....3500 m3 /h

- Fuel for heating.....diesel DIN EN 590

- Power supply.....24 V DC

- Nominal alternator current equation after the regulator.....200A

Table 2. Temperature range within of the working environment space in °C

time	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
11.45	40.5	40.6	38.7	37.7	37.7	36.9	41.2	37.1	37.6
11.55	37.4	38.7	37.1	35.2	35.8	34.2	41.4	34.7	35.7
12.05	35.5	37.0	36	33.8	34.7	32.4	40.6	33.2	34.3
12.15	33.9	35.6	34.9	32.4	33.6	31	39.6	31.8	32.8
12.25	32.7	34.4	33.9	31.4	32.8	30	38.6	30.7	31.5
12.35	31.65	33.35	33.06	30.4	31.8	29	37.6	29.7	30.5
12.45	31.3	32.9	32.6	30	31.3	28.6	36.8	29.3	29.8
12.55	31.2	32.4	32	29.5	31	28.2	36.4	28.9	29.2
13.05	30.6	32.4	32.1	29.4	30.4	28.5	36	29.1	29.9
13.15	30.1	32	31.6	28.7	29.9	**27.7**	35.9	28.3	28.9
13.25	28.9	31.5	31.1	28.3	28.8	**27.3**	35.2	**27.6**	**28**
13.35	28.5	30.7	29.9	**27.1**	**27.9**	**26**	34.3	**26.2**	**26.2**

3.RESULTS AND DISCUSSION

In order to determine the relationship and connection of the TSV readings, and to calculate the PMV factor, the following equation was used, which is part of the Fanger criteria for evaluating environmental parameters according to the ISO 7730:2005 standard, we calculated it with the following equation:

$$PMV = PMV\ (ta, tr, va, pa, M, Iclo) \quad (1)$$

It is also necessary to tabulate the instruments with which the measurement was performed, in order to clearly define the distribution of results when measuring the response speed of the sensor (transducer) table 3.

Table 3. dilation of the results during the test

Measuring device	Parameter	Measuring range	Measuring accuracy
Globus B&K 1212	Radiant temperature	±50 °C	±0.5 °C on ±15 °C ±2 °C on ±50 °C
PeakTech 5180	Air temperature	from -40 °C to +70 °C	±1 °C
	Relative humidity	from 0 to 100 %	±3 %

We will also show two diagrams, the first diagram of which refers to the first measurement in the storage conditions of armored combat vehicles figure 2.

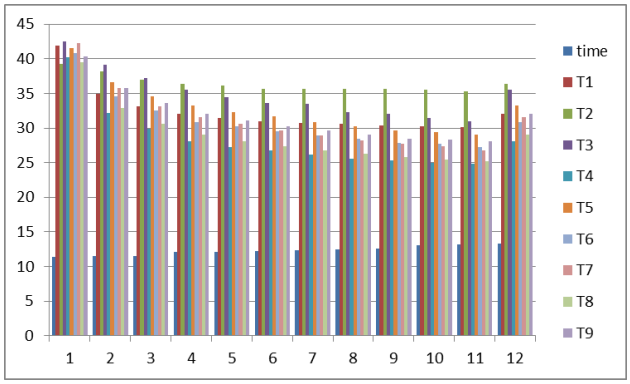

Figure 4. storage conditions of armored combat vehicles

Second diagram to the second measurement in real working conditions of armored combat vehicles figure 3.

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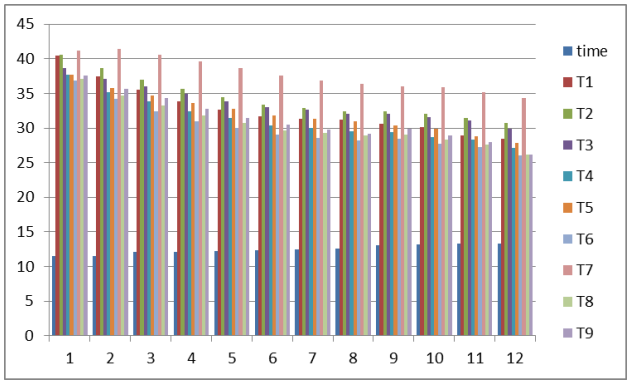

Figure 3. real working conditions of armored combat vehicles

4. CONCLUSION

Based on all the obtained results, we come to the following conclusions:

1. Thermal comfort of armored fighting vehicles depends on how the vehicle is handled when not in use.

2. The thermal comfort of the space for the crew is better and more pleasant if there is a possibility of storing armored combat vehicles, before they are put into use. This exactly means that one of the necessary and sufficient conditions to improve the crew's comfort is that tools that are not in use are adequately stored in a suitable space.

3. the fact that there are better results in the storage area is supported by the fact that in the first test of armored combat vehicles that were tested in storage conditions, we justify that four measuring points met the requirements of the set standards with an accuracy of seven results. While in the case of combat armored vehicles whose thermal comfort was measured in real working conditions, the same was achieved by four workplaces, but with an accuracy of two results within the required standards.

4. The response speed of the meters also varies by a full five minutes, which is a large delay in the response of the meters if you take into account that the transmitter is calibrated to respond for ten seconds.

5. It should be noted here that the examination could be improved if there were crew members of different grades, because in that case the parameters for evaluation according to Fanger's criteria would change.

References

[1] ANSI/ASHRAE Standard 55-2020, *American Society of Heating, Refrigerating and Air-Conditioning Engineers*, 2021.

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[3] Fanger, P., *Thermal comfort: analysis and applications in environmental engineering, Danish Technical Press*, Copenhagen, Denmark, 1970.