RENEWABLE ENERGY SOURCES IN THE CASE OF CRISIS SITUATIONS

Peter LIPTÁK[1]* – Ivan KOPECKÝ[2]

[1] *Peter Lipták, Faculty of Special Technology, Alexander Dubček University of Trenčín, Pri parku 19, 911 06 Trenčín. Slovak Republic.*

[2] *Ivan Kopecký, Faculty of Special Technology, Alexander Dubček University of Trenčín, Pri parku 19, 911 06 Trenčín. Slovak Republic*

*Corresponding author E-mail address: peter.liptak@tnuni.sk

Abstract

Operation of special equipment is possible in crisis situations. It is because special equipment is designed for operation in non-standard often extreme conditions and situation, it is available, it has a high degree of crossing capability and it is able to provide basic living conditions even in field, e.g. provision of power for hospital, transportation of wounded and injured persons, supplies, medical care in field conditions, delivery of potable and utility water etc. The authors in the paper deal with a possibility to provide electric energy through advanced renewable sources, especially in meeting tasks in areas with no public mains, possible supplies of potable and non-potable water, embedding such assets into mobile systems. The authors in publication summarize results of research within the „Use of renewable sources of energy in practice“project. System of modeling and computer-aided simulation of renewable sources of energy has been proposed within this project. Application of a system for designing of power systems in logistic containers is expected. The knowledge on power balance of logistic containers operated by the SR Armed Forces in missions abroad is summarized in the last chapter of the paper.

Keywords: Crisis situations, renewable sources of energy, photovoltaic collectors, logistic container, power systems, mobile assets of crisis management

1 Introduction

To provide basic human needs in solving crisis situation there is a need to provide an affected area with energy and water. The authors within a research program have been solving such provision assuming that equipment will be deployed in different environs and will use energy from solar radiation and wind energy as well in addition to standard initial energy and power supply. Mobile solution has been proposed, namely embedding the equipment and devices into containers that are transportable to a destination by a rotor-wing by a truck or a vessel. One of the prepositions for a possible commissioning of the equipment is a presumption of a machine quality and its reliability, equipment within limits of operational parameters. In operational practice of special equipment, e.g. machines and equipment (engineer equipment) the repairmen and operators challenged a task to create conditions to use some selected equipment, e.g. electric devices and appliances in critical situations as well, e.g. in humanitarian relief, , in military and peace observation missions of international organizations or within international exercises. With regard to a fact, that nearly always in such situations machines and equipment is to be deployed, including electric machines, the experience in this area was generalized as a background aiming to start a technical preparation for next missions and their logistic support.

2 Materials and methods

Under a „CRISIS SITUATION“notion for purposes of this paper we understand an unplanned, specific situation resulting in:

- Threat to persons, environment, property in a larger scale.
- Presumptions for a rise of such situation can be determined only with a low probability.
- The situation occurs resulted from an unpredictable environmental situation (e.g. disasters and casualties, earthquakes, floods etc.), from unpredictable activity of persons (e.g. terrorist attacks etc.), unthinkable crashes of systems and facilities, (e.g. nuclear power plant accident resulting from disasters etc.), and other unpredictable situations.

From a point of view of providing a solution for such situation there is a need to be ready for such solution in terms of being equipped with appropriate equipment, material, and assets. The authors of the paper deal with a special equipment under their purview.

Quality and operational reliability are the basic requirements laid on special equipment. Under quality and operational reliability notion for this paper we are considering quality of a whole technological cycle, quality of a machine and facility as a whole.

In literature an operational reliability (or service dependability) notion is characterized as a feature of a product enabling meeting specified functions within the permitted tolerance under given operating conditions and in a requested operating period [1]. Service dependability of a product, facility, and machine in particular contains ability:

- To work permanently within the permitted tolerance of required parameters,
- To keep a repair ability (to retain a possibility to remove failures),
- To withstand a short-term overloading (resistance of the product),
- To work for a certain period even with small damages, i.e. with worsened operating parameters (product´s viability),
- Maintenance undemandingness and its small range (maintenance friendliness and efficiency).

From a user point of view the reliability is perceived as an integral set of technical, qualitative, economical, ergonomic and other properties of a product, influencing its total technical life [2]. Within reliability theory we differentiate:

- properties,
- reviewed areas and their basic characteristics,
- phenomena, conditions and activities,
- variable working values,
- failures,
- indicators of reliability,
- Indicators of a failure-free operation
- life-cycle indicators,
- indicators of storage stability
- indicators of maintainability
- complex indicators
- testing,
- backup.

As extreme conditions are considered all conditions, that are beside values being typical for Central European temperate climate zone, Tab.1.

Table 1 *Characteristics of a temperate climate zone*

The lowest temperature of air	-40°C
The highest temperature of air	+40°C
The highest relative humidity	95%
The highest absolute humidity	60 g.m^{-3}
The highest intensity of solar radiation	1120 W.m^{-2}
The highest intensity of thermal radiation	600 W.m^{-2}
The highest speed of air	20 m.s^{-1}

Table 1 *Table Caption*

No	**Pressure [MPa]**	**Processing conditions**
1a	400	debinding
1b	600	debinding
2a	400	debinding, ECAP-BP
2b	600	debinding, ECAP-BP
3a	400	debinding, sintering, ECAP-BP
3b	600	debinding, sintering, ECAP-BP
4	100	annealing
5	0	hardening

Area, in which the selected equipment and machines were reviewed, is characterized as environs with increased corrosion aggressiveness, dusty environment with nonflammable dust, however the one deteriorating dielectric permittivity and electric piercing strength due to its conductivity, environment with quakes and environment with biological vermin.

Various types of simulation chambers are used when simulating the effects of environment on parts and devices. Inside these chambers there is such simulating environment established, where the product application is supposed to be, e.g.:

- Humid heat trial – cyclical mode
- Humid heat trial – acyclic mode
- Mildew trial
- Air-tightness trial
- Solar radiation trial

- Atmospheric pressure trial
- Temperature alternation trial, frost trial
- dry heat trial
- salt-haze trial
- low pressure trial
- dust trial.

In case when equipment is deployed in conditions with an increased concentration of air pollutants in long-shore areas we recommended the following tests:

- corrosion test in a condensation chamber – to verify resistance of materials and surface protection, when it relates an effect by an increased humidity or an increased concentration of SO_2 with no other effecting factors,
- corrosion test in a salt haze – verifies material resistance and surface protection in long-shore atmosphere with a decisive factor – a sea water aerosol,
- solar radiation trial– verifies the product resistance to light and thermal effects of solar radiation,
- dust and sand trial – simulation of desert conditions,
- dry and wet heat test,
- mildew trial – simulation of material having been biologically invaded,
- vibration trial.

These trials has been proved by a next operation of equipment and material in practice, e.g. in areas of equatorial Africa and on Cyprus Island. As we monitored the renovated objects, we chose the failure and renovation flows as reliability criteria. Properties of renovated objects are expressed by $\mathrm{H}(t)$ value, a mean number of failures of a renovated object for t period:

$$\mathrm{H}(t) = \frac{1}{N}\sum_{i=1}^{N} n_i(t) \tag{1}$$

where $n_i(t)$ is a number of failures of the i-th renovated object during t operating period, N is a number of objects being reviewed. From statistics point of view, a failure flow characteristics is appropriate, that we expect in a short time period Δt. This characteristic is expressed by a relation:

$$\hat{h}(t) = \frac{\Delta \mathrm{H}(t)}{\Delta t} = \frac{\sum_{i=1}^{N}\left[n_i(t+\Delta t) - n_i(t)\right]}{N.\Delta t} \tag{2}$$

where $\Delta \mathrm{H}(t)$ is an increase of an average number of failures for a short time interval Δt, or an average number of failures in a time interval $(t,t+\Delta t)$. Due to statistical assessment of a real number of failures during year operating period, it was possible to consider, that the failures of a renovated object are ruled by an exponential rule of distribution with a λ failure intensity. In a particular situation, Tab.3, was a value of a mean number of failures of a renovated object for 1 operating year (tests were made 1 month after completion of a rain season) a number from interval (0, 1 – 0, 4) in a so called stable state of reliability (test run was made before exporting abroad, in ageing state we do not recommend to operate an equipment abroad).

Coefficient of technical usage:

$$K_{tv} = T/\left(T + T_p + T_o\right) \tag{3}$$

is a readiness coefficient:

$$K_p = T/\left(T + T_o\right) \tag{4}$$

where T is an average period between failures of a renovated object, T_p is an average period of a shut-down, T_o is an average repair period. From a view of a possible increase of machine and equipment reliability, being operated in climate conditions we have chosen a backing up method. Backup is one of basic methods in improving reliability of machines and equipment. This relation is applied for parallel arrangement of elements (Fig.1):

$$R_p(t) = 1 - \prod_{i=1}^{k} 1 - \exp\left[-\left(\frac{t}{a_i} \right)^{b_i} \right] = 1 - \prod_{i=1}^{k} F_i(t) \quad (4)$$

where $R_p(t)$ is a failure-free operation of a parallel system, $F_i(t)$ is a probability of a failure risk in particular elements of the system.

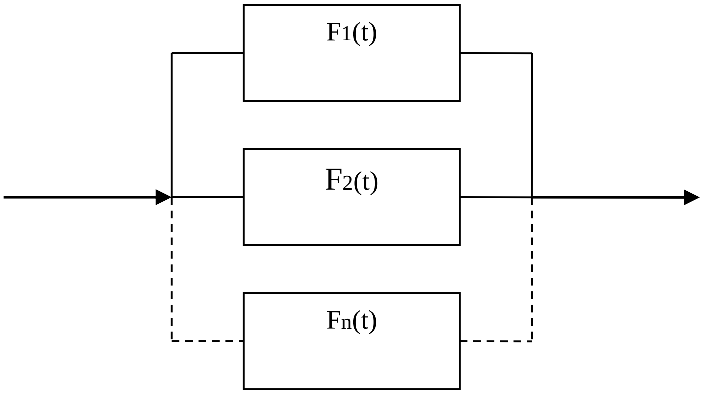

Fig.1 *System of elements with parallel arrangement of elements*

Relation of increasing reliability of the system to the number of elements in a parallel arrangement [1] is in the Fig.2.

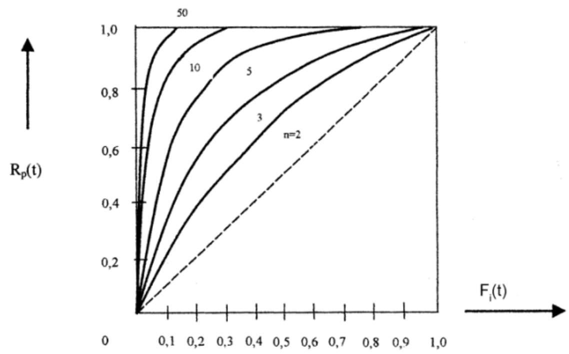

Fig2. *Relation of a probability of a parallel system failure less operation to a number of elements*

Even though a backing up increases a complexity, so its acquisition costs, in a probable deployment for special tasks in extreme climate conditions, this method has been proved as a suitable.

From a view of a special equipment crisis management the following needs have been considered:

- Access and availability, ability to pass a water obstacle; mud, mountain and forest terrain, on the road and by air.
- Mobility and equipment and systems transportation.
- Provision of electric energy.
- Provision of potable and non-potable water.
- Provision of medical and health service.

For purposes of this paper we are presenting possible ways how to provide for electric energy, potable and service water supplies and a container system to transport such equipment and systems.

2.1 Current electric energy sources used for mobile logistic assets in ISO 1C containers

Electric source units in ISO 1C containers are assigned for a production and distribution of electric energy as a backup source to provide operation of electric facilities in field conditions. They include a drive unit, a plant producing electric energy, transformer station and distribution wiring net. The power block is installed in the ISO 1C container, it is sound and thermal proof, tempering and airing is provided with embedded exhaust blowers and through orifices with closing blinds for airing. The container floor is designed as a leak-proof tub assigned to catch possible leakage of operating liquids. The container includes a sales stock for distribution wiring and power block accessories. ISO 1C container is equipped with large door with a visor and detachable panels for an easy access for a quotidian maintenance [3].

2.2 Electric sources requirements for mobile assets

One of the most important requirements to electric sources for mobile assets is applicability in a micro climate area with an N14 (STN 03 8206) climate:

- Temperature ranging from -35 °C to +55 °C,
- Relative humidity of air up to 30% at temperature of +25 °C,
- Velocity of air flow up to 20 m.s^{-1} from all directions,

Atmospheric precipitations in form of rain with intensity of 3 mm.min^{-1} falling 30° angle wise in all directions. [4]

They need to be produced so that can be connected to several kinds of distribution systems:

- TN – C, 3 + PEN, 400/231 V – the most common four-line wire distribution system,
- TN – S, 3 + PE + N, 400/231 V – distribution system used in the world,
- TT, 3 + PE + N, 400/231V – distribution system, which is not much used, however it exists in electric wiring of special equipment,
- IT, 3 + PE + N, 400/231 V – an isolated system being used mainly in special or medical equipment and in power equipment for insular power facilities. [5]

***Table 2**. Electric installation parameters of some logistic container working places*

Designation and marking of a logistic container	Voltage system	Maximum power input (kW)	Output of a source itself (kW)
ISO 1C container – social	TN.S 3+N+PE 400/230V AC 50Hz	18,2	0
ISO 1C container – water tank	TN.S 1+N+PE 1x 230V, 50Hz	1,25	0
ISO 1C container – accommodation 2-bed	TN.S 3+N+PE 400/230V AC 50Hz	5,5	0
ISO 1C container – accommodation 4 bed	TN.S 3+N+PE 400/230V AC 50Hz	5,5	0
ISO 1C container – briefing folding 3- wall	TN.S 3+N+PE 400/230V AC 50Hz	7,5	0
ISO 1C container - office	TN.S 3+N+PE 400/230V AC 50Hz	6	0
ISO 1C container – refrigerator for deceased	TN.S 3+N+PE 400/230V AC 50Hz	5,1	0
ISO 1C container – refrigerator, two chamber	TN.S 3+N+PE 3x 400V, 50Hz	4,8	Combustion engine
ISO 1C container – surgery ward	TN.S 3+N+PE 400/230V AC 50Hz	9,5	

ISO 1C container – mobile workshop asset of „A", "B" and "C" types	TN.S 3+N+PE 400/230V AC 50Hz	15	5,1

3 Conclusion

Experiences with operating the equipment in crisis and extreme conditions have proved a possibility to export and deploy machines and weaponry equipment of the SR Armed Forces into extreme climatic conditions, e.g. out of European conditions etc. With regard to development of combat activities within the theatre of operation, where a single concept in equipment is preferred in different climatic conditions, an importance of equipment adaptation to operation in various conditions is still increasing. Such adaptation is to be taken into consideration in designing equipment, as well as during logistic support of their activities as well as in planning their operation. Also published lessons learned showed a possible economical approach e.g. through a possible extension of a lifetime of some technical equipment (pressure vessels, heavy current equipment, lifting equipment) with a sustained needed operating reliability.

In terms of integration into security structures the published paper relates with a need to implement a single system of quality assessment, codification and standardization. In future it is needed to pay attention to this area with regard to a unified assessment of an operating reliability of special equipment.

References

[1] KRUŽLIAK, J. *Prevádzková spoľahlivosť, diagnostika a údržba ženijných strojov.* Liptovský Mikuláš: Vojenská akadémia Liptovský Mikuláš, 2002.
[2] BUKOVECZKÝ, J., BÍLÝ, M. *Životnosť a spoľahlivosť strojov.* Bratislava: SVŠT Bratislava, 1986.
[3] ŠÚRI, M., 2006. Solar Electricity and Prospects of its Generation in Slovakia. *Životné prostredie*. **40**(3), p. 127–132.
[4] MIKURČÍK, J. 2003. Kodifikačné minimum. *BULL-1-3*, Bulletin č. 3, VSVaP Trenčín
[5] LIPTÁK, Peter, KOPECKÝ, Ivan, GALETA, A. *Špeciálna technika. Časť Stroje a zariadenia.* Trenčín, 2005. ISBN 80-8075-053-X.
[6] ÁČ, Vladimír. 2015. *Modelovanie a počítačové simulácie systémov obnoviteľných zdrojov energie,* Čiastková správa z riešenia projektu ITMS č. 26220220083. Trenčín: TnUAD v Trenčíne
[7] KOPECKÝ, Ivan, RAKÚSOVÁ, Dana. 2014. Hybridné fotovoltické zariadenia v urbanizovaných prostrediach. *TRANSFER 2014 - 15. medzinárodná vedecká konferencia, Trenčín, 23.–24. október 2014*
[8] Dostupné z: http://www.voptrencin.sk/sk/vyvoj_vyroba_k_upr.htm
[9] Dostupné z: http://www.nuovaenergia.eu/sk/hirek/Spotreba-pitnej-vody/139/2/
[10] Dostupné z: http://www.voptrencin.sk/sk/vyvoj_vyroba_k_upr.htm