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FACTORS ENDANGERING HIGHLY PROTECTED SHELTERS AND THEIR PERSONNEL

A NAGY VÉDŐKÉPESSÉGŰ ÓVÓHELYEKET ÉS A BENNÜK TARTÓZKODÓKAT VESZÉLYEZTETŐ HATÁSOK

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Abstract

The determination of the requirements of designing, constructing and operating highly protected facilities may seem to be a simple task. But often, because of the possible impacts, it is difficult to determine them. Even the constructor cannot accurately specify the requirements and needs to the designers. It can be stated that this is a complicated and complex task requiring a high level of professional knowledge and experience. One needs to know the threatening impacts and the endangering factors in their entirety; they need to be aligned with the most unfavorable national defense policy expected in the long run, and one must be able to implement them. Knowing all this, one needs to determine the level of protection, so that risks can be minimized. These facilities should be integrated into the operational plans. Unfortunately, probability calculations are often not performed because of their complexity.

Keywords: *protected facility, specially fortified facility, endangering factors, risk factors, design requirements, protection capacity*

Absztrakt

Nagy védőképességű védett létesítmények tervezéséhez, kivitelezéséhez és üzemeltetéséhez a követelmények meghatározása egyszerű feladatnak tűnhet. De gyakran előfordul, hogy a nehezen meghatározható hatások miatt az építtető sem tudja pontosan megadni a követelményeket és az igényeket a tervezők számára. Kijelenthető, hogy bonyolult és komplex feladat, mely magas szintű szakmai tudást és tapasztalatot kíván. A veszélyeztető hatásokat és tényezőket maradéktalanul ismerni kell, össze kell hangolni a hosszútávon várható legkedvezőtlenebb nemzeti védelmi politikával és tudni kell azt alkalmazni. Ezek tudatában kell a védelmi szintet kialakítani. Így kockázatokat minimalizálni lehet. Ezeket az üzemeltetési tervekbe is be kell építeni. Sajnos a valószínűségi számításokat bonyolult voltuk miatt gyakran nem végzik el.

Kulcsszavak: *védett létesítmény, speciális erődítési létesítmény, veszélyeztető hatások, veszélyeztető tényezők, kockázati tényezők, tervezési követelmények, védőképesség*

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ANTECEDENTS

Protected facilities are structures where, beyond ensuring physical protection and living conditions, also providing high-level working conditions and communication are basic tasks. [1] They have the functions, often separately or conjointly, of a command post and a shelter. They are built largely as state investments, so they fall within the scope of state fortification. They are also called as specially fortified facilities in the Hungarian terminology.[1] These facilities are generally shelters with physical protection capacity Class III according to the Hungarian classification[2] [3] [2; p.15.], but in special cases, they may have different protection capacities. The vast majority of the highly protected facilities[4] are located underground. They have significant advantages in camouflaging, especially in concealing (see at the end of this paper at the topic of camouflaging).

Such specially fortified facilities are located in many places in Hungary, the smaller part of which is still maintained by various state organizations. [3; pp.5-6.]

When designing such facilities it is difficult to determine to what effects they should be sized and prepared. It often happens that, due to the impacts that are difficult to determine, even the constructor cannot accurately specify the requirements and needs to the designers.

In Hungary, no required design requirement has ever been mandatory in relation to these facilities: designers used the no longer valid Technical Guidelines and other hard-to-access old recommendations for designing shelters.

In this paper, I have collected the factors that may jeopardize the specially fortified facilities, especially those that may affect Hungarian facilities. I have tried to present examples of all the factors and specific hazards, endangering the structures and the personnel inside. Along with the possible hazard sources, I have demonstrated some practical examples of specific incidents.

The appearance of the “Scalpel” operational theory and the continuous development of offensive weapons have further increased the demand that our fortified facilities our fortified facilities should ensure adequate protection, designed to an acceptable risk level, primarily for the personnel and the communication equipment, however, their implementation should stay in the framework of reasonable economy. [4]

RISK FACTORS AND THEIR GROUPING

Apart from the designers of specially fortified facilities people may easily have an impression that these facilities should only be sized against the impacts of a small number of offensive weapons. I have shown that the entirety of the jeopardizing impacts is much more complex. I have endeavored to collect the endangering impacts (and their real risks) with as much detail as possible. Knowing them, one can be prepared efficiently and economically against them.

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[1] Terminology originating from the translation of Russian literature.

[2] Shelters are classified in five classes in the Principles of Engineering in Hungary as per the frontal pressure of the shock wave: Class I shelters must resist a value of 2.0 MPa, Class II shelters 1.0 MPa, Class III shelters 0.5 MPa, Class IV shelters 0.1 MPa and Class V shelters 0.03 MPa.

[3] In certain literatures, Class I shelters are to be designed to resist more than 1 MPa load without upper limit.

[4] In this paper, I call the facilities with high protection capacity, which, regarding their physical protection capacities, can be classified as Class III, and as far as their engineering systems, they are equipped not only with means capable of sheltering from the outside air, but also capable of regenerating air.

OFFENSIVE WEAPONS	**By type**	conventional
		nuclear
		special (e.g., generating electromagnetic impulse (EMI) or neutron weapon)
	By location of impact site	air
		ground
		underground
		underwater
	By location of launch site	remotely launched
		onsite external
		onsite internal
	By destructive impact	generating shock wave (and suction effect)
		generating electromagnetic impulse
		generating light and/or heat
		generating radiation
		generating toxic gases
		aerosol (generating incendiary or explosive gases)
		Contact-destroying impact
HUMAN FACTORS	defining incorrect and incomplete criteria	
	incorrect and wrong design	
	incorrect and wrong construction	
	unskillfulness and inability of operating personnel	
	unauthorized physical intrusion (organized attack of combatant units or accidental intrusion by an alien or the appearance of the fleeing civilian population or terrorist attack)	
	revenge, sabotage	
	bribery, industrial espionage, extortion	
	disregarding confidentiality, releasing critical information, missing encryption and required rules, non-compliance thereof	
	violation of rules and indiscipline	
	unauthorized intrusion into the control system	
	lack of documentation for the operation	
	improper or poor maintenance	
	psychic exhaustion of the personnel inside	
LACK OF LIVING CONDITIONS	lack of oxygen (enrichment of carbon dioxide)	
	lack of water	
	lack of food	
	lack of fuel	
	overheating	
	lack of healthcare conditions (e.g., lack of medical care, instruments, medicine, disinfectant)	
NATURAL IMPACTS	earthquake	
	flood, tsunami	
	lightning	
	wild fire	
	geological and hydrogeological changes	
OTHER IMPACTS	industrial or chemical disaster	

	operational disruption
	internal fire
	internal explosion (e.g., an equipment or machine)
	ever accelerating technical development
	lack of camouflaging (concealment, pretense, deception, demonstration)
	changes in the national defense policy and the willingness of the current government to allocate financial means
	lack of external and/or internal communication

Figure 1: Summary of endangering factors in a table format [5]

DETAILED DEMONSTRATION AND ANALYSIS OF RISK FACTORS

Grouping of offensive weapons by type

Conventional offensive weapons contain explosives, which, during explosion, are transformed into gases, so that their volume grows to multifold in a short time, thus they perform work. The high temperature and pressure gas, located concentrated, suddenly begins to expand. This creates a shock wave in the ambient medium (later, a minor intensity suction effect). [6] Although the temporal feature differs from the thrust wave to the shock wave created by an atomic bomb, they are just as dangerous as the latter. From the magnitude of the warhead (TNT equivalent mass)[5], calculating from the energy released, the value of the pressure on the dimensional structures of the facility to be fortified can be defined. Conventional weapons, even though they are still used nowadays in great numbers, yet they cannot produce the greatest impact, but nuclear weapons.

Nuclear weapons appeared in 1945. Their destructive power is much greater than that of conventional offensive weapons. Their shock wave effect on the specially fortified facilities is similar to those of conventional weapons, but they also have other, high intensity effects. In the case of aerial or ground explosion, as far as the order of their arrival, electromagnetic impulse is the first of the effects on the facility to be protected. The following are light and heat radiation. The third one is the thrust wave, the next one is the initial, then the secondary radiation. (In the case of underground explosion, there is a significant difference between them and some of the effects will be lost.) In a very short period (practically zero time), a large amount of energy is released that warms up suddenly the surrounding medium and the high temperature materials; during their thermal expansion, they produce a similar shock wave as conventional weapons.

[5] TNT equivalent is a data compared to the amount of energy released at the explosion of 1 kg of trinitrotoluene explosive.

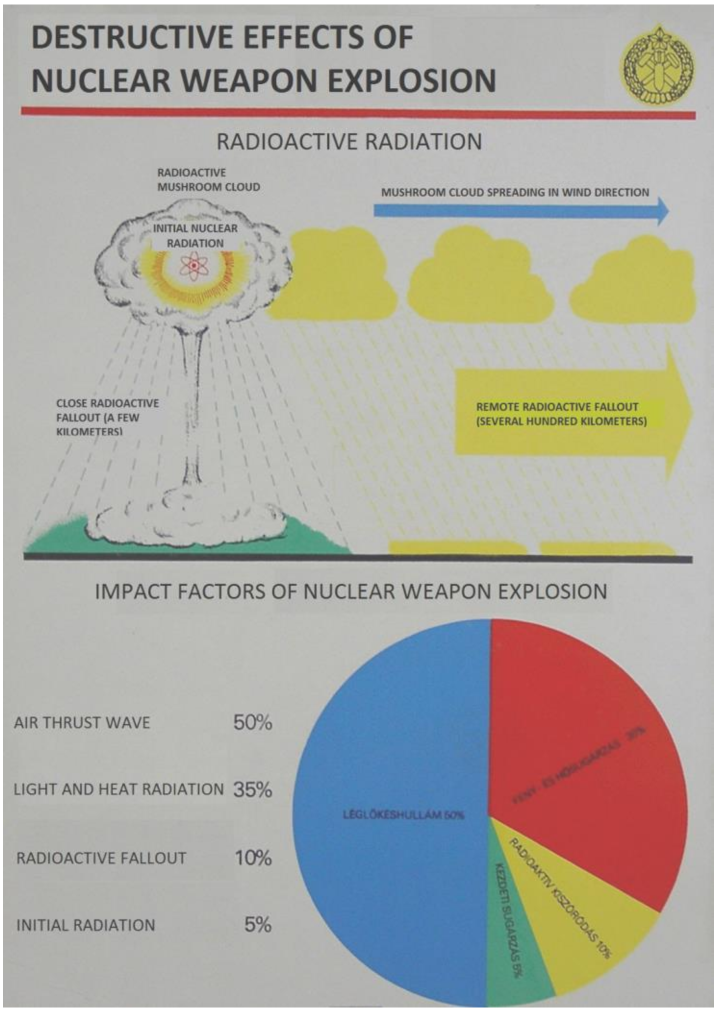


Figure 2: Destructive effects of a nuclear weapon explosion [7]

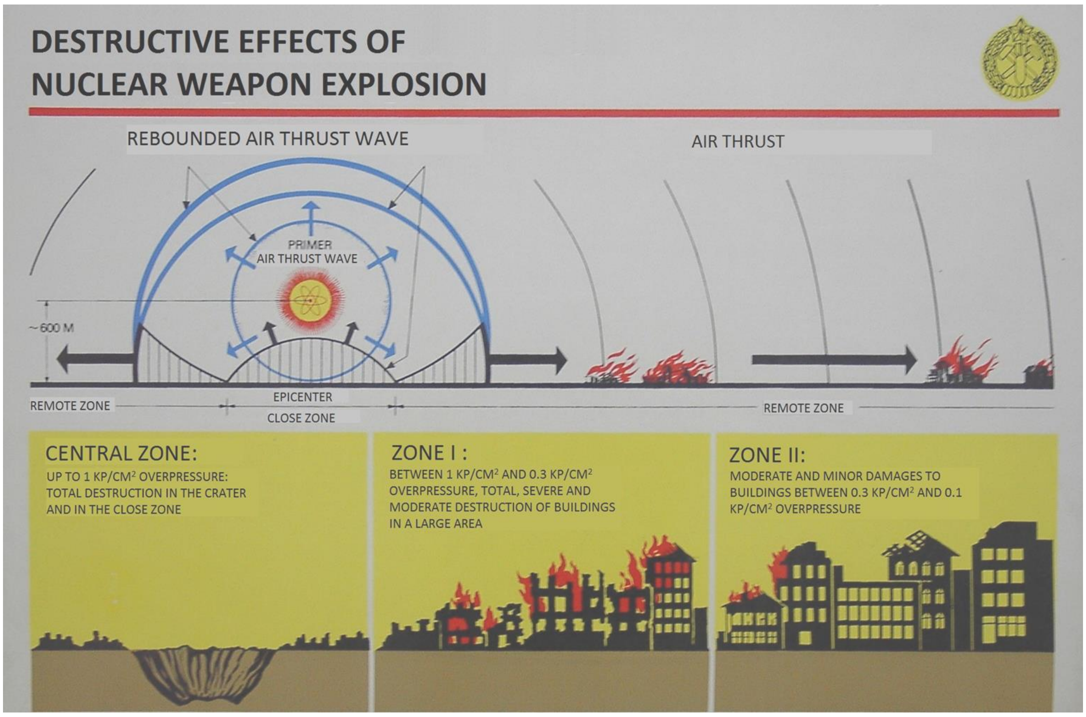


Figure 3: Destructive effects of a nuclear weapon explosion [7]

Here, too, there is a suction effect with a lower intensity and occurring later during the shock wave that occurs at the return of displaced fluid to its original (or nearly original) place. The radiation is very harmful to the organism, so, it has to be protected against it. Electromagnetic impulse (EMI) protection is inevitably necessary for electrical current in the instruments and devices, since without it, the effect may be fatal. Electrical devices must be protected even when they are off (current-free) as they are caused by EMI, high voltage is generated and they are deteriorated. Besides these weapons, nowadays, there are a number of other special weapons.

Special offensive weapons strengthen or amplify the secondary effects observed at other weapons. Such is EMI. A similar one is the neutron weapon, but with them, very detrimental effects are witnessed in organisms. It ionizes water molecules with which the cells constituting the human body are no longer capable of biological functions.

Grouping of offensive weapons by the location of impact

In the event of an *aerial explosion*, the explosion occurs at an altitude of over 300 meters above the surface. The shockwave is spread in the air (gas), then some of it passes to the solid surface and the other part is reflected. Underground protected facilities are endangered by air pressure (shock waves) generated by surface connections, as well as by induced shock waves spreading in the solid, infinite half-space[6] as well. The explosion may also occur lower which is called a surface explosion.

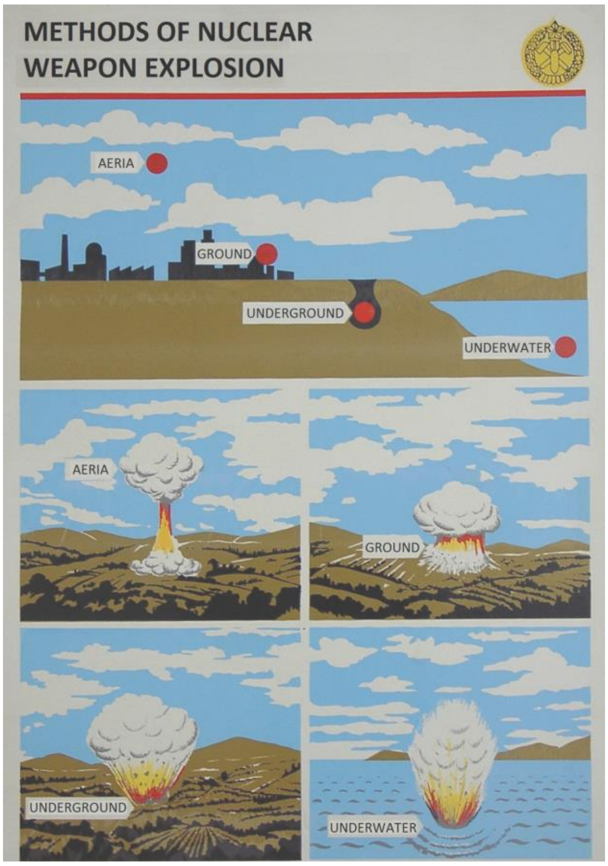


Figure 4: Modes of nuclear weapon explosion by location [7]

[6] The infinite solid half-space is the ground mass under the surface, above which air (and not soil) is located.

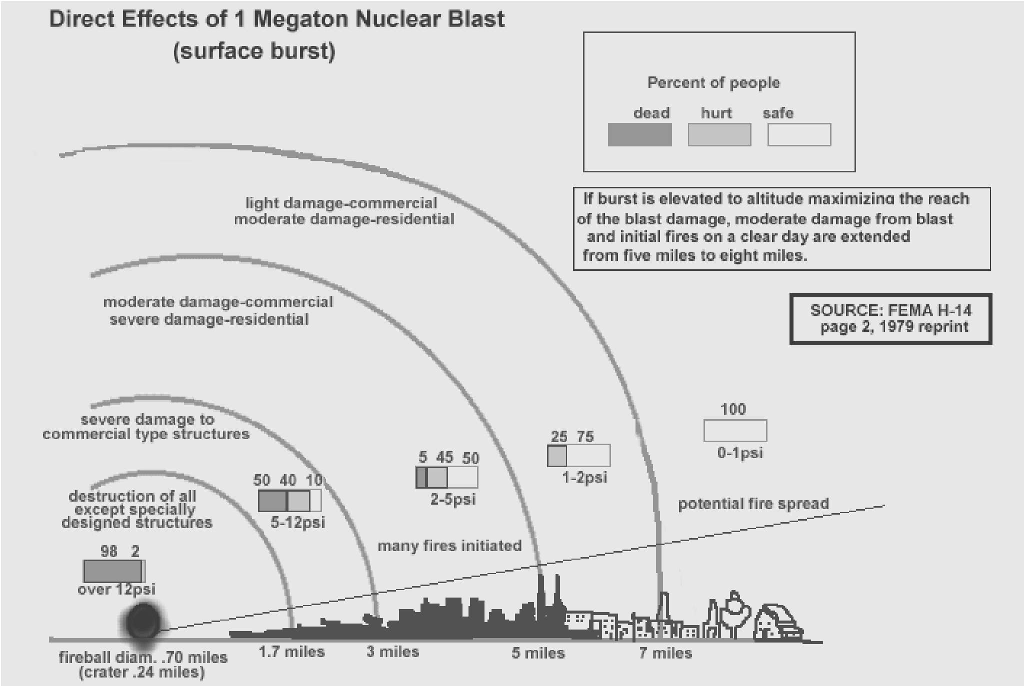


Figure 5: Immediate impacts of the surface explosion of a 1-megaton nuclear bomb [8]

In the case of *ground explosion*, the explosion occurs at a maximum height of 300 meters from the surface. The pressure wave is spread in the air (gas), then some of it passes to the solid surface and the other part is reflected back. Underground protected facilities are endangered by air pressure (shock waves) arising at surface connections, or shock waves induced and spreading in the solid, infinite half-space. This causes less physical impact than the aerial and underground explosions. The explosion can occur even lower.

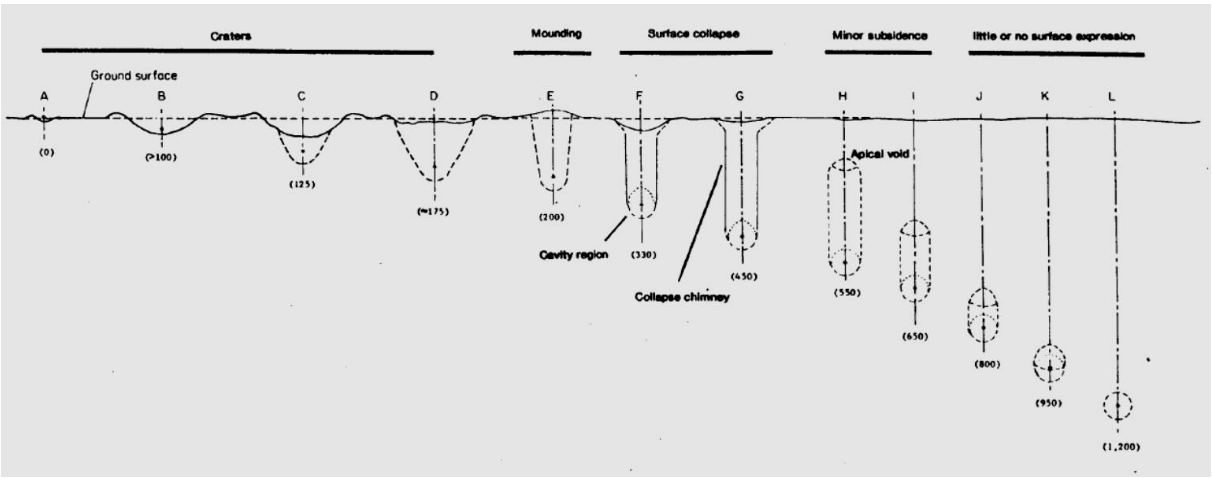


Figure 6: Crater formation depending on the burial depth in solid rock in the Nevada Test Area [9]

In case of *underground explosions*, as it is called, there is a detonation point (hypocentrum) located beneath the surface. It is usually possible that the carrier delivers the offensive weapon under the ground. Such devices have been in place for a long time and are able to penetrate even to a great depth. The near-surface explosion of high-load charges takes place partially suppressed, therefore, rejection and fallback occur. If the explosion happens deep, the rejection is complete and sinking and a crater is formed on the surface. If it occurs at very low depths, a lasting effect will not be visible on the surface. The effect on underground objects is very dangerous despite the fact that in solids (soils) damping is relatively high but the detonation point may fall close to the facility. In some cases, the medium may behave as a non-solid (or liquid).

Offensive weapons, coming close to the protected facility at a vertical impact angle and then trying to penetrate into the ground under an oblique angle below the facility and create a delayed explosion are particularly dangerous. [5]

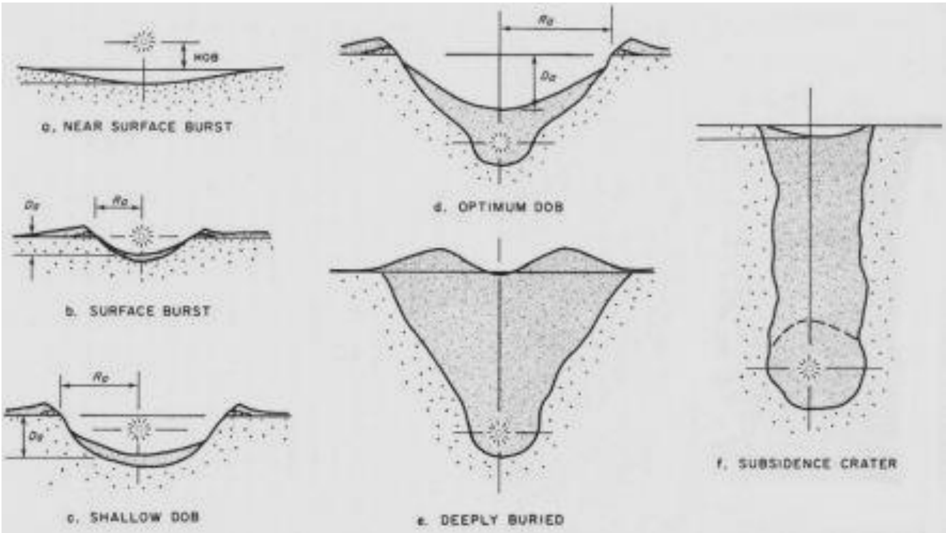


Figure 7: Crater formation depending on the position of the explosion [9]

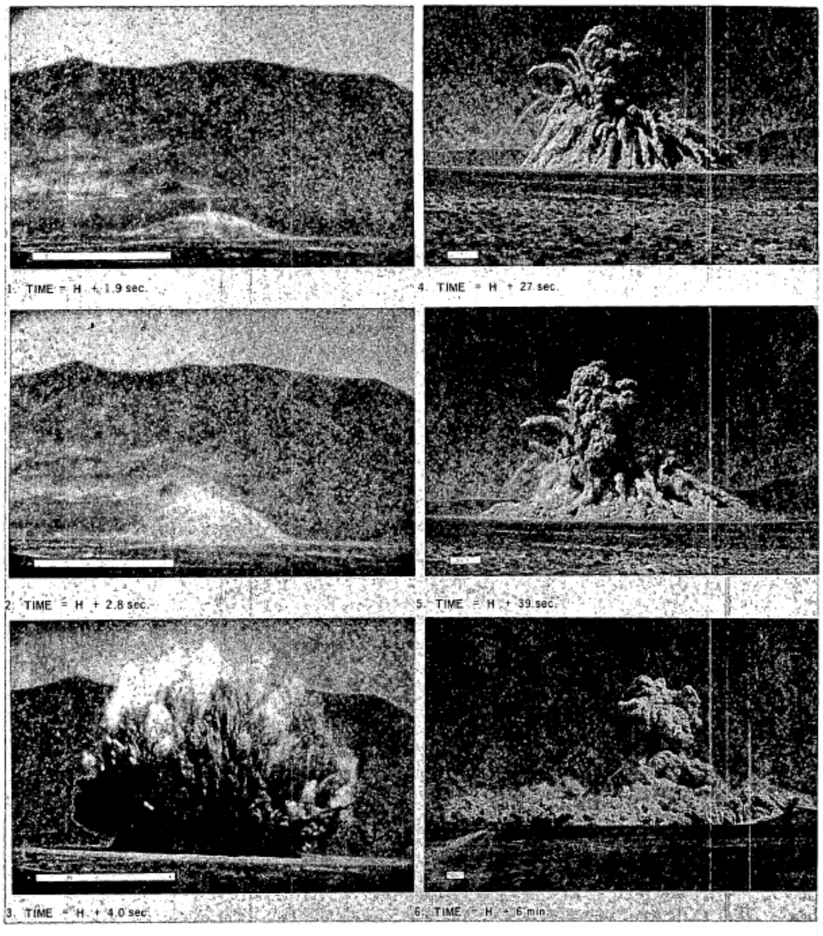


Figure 8: Pictures of the Sedan atomic bomb (104 kt) at the time of the explosion near the surface [10; p.10.]

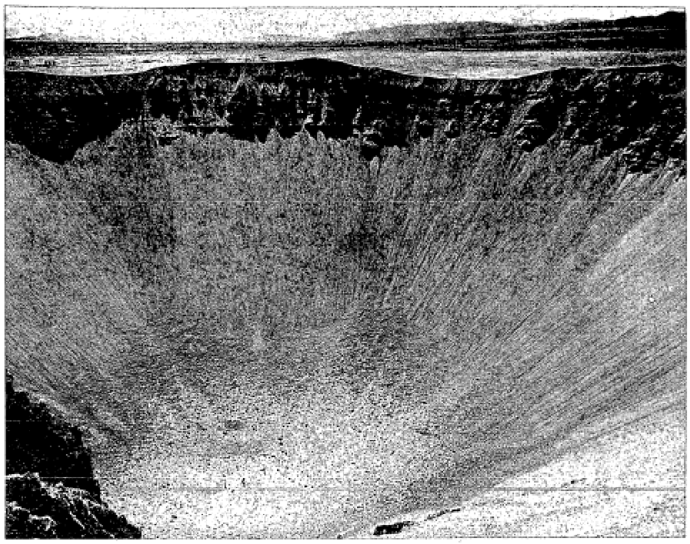


Figure 9: A crater with a 384-meter diameter and 100-meter depth on the Nevada Test Area created by the Sedan atomic bomb (104 kt) at an explosion near the surface [10; p.22.]

Explosions can take place even *underwater*, but since such facilities are not built underwater, I will not go into details in this article.

Grouping of offensive weapons by the location of launch site

Remote launching today is the most used delivery method against specially fortified facilities. Accordingly, it is common to see that its accuracy is also very high. 1-meter accuracy is not uncommon in the warfare of developed nations.[7]. They are quite dangerous, as they can be effectively used for attacking surface facilities of the enemy. Furthermore, the delivery means of so called bunker-destroying bombs that penetrate into a great depth also belong to these types. Due to technologies, only a handful of developed nations possess them, where the money needed for their development is available. Depending on their launch position, the weapons may be close launched ones.

Onsite weapons externally launched but with internal impact are offensive weapons launched from a medium distance (in visibility). Their magnitude is generally smaller than that of remote ones, but there may be exceptions, for example, if a facility is built near a coastline, it can be a warship's guns[8] or weapons more accurate at smaller distances, or when long-range weapons cannot reach their targets because of terrain obstacles. These weapons may, in some cases, be internal launched weapon[9] as well.

Onsite weapons internally launched may be the most dangerous ones in some cases, as we face an internal explosion. A great destructive effect can be achieved with them. At this time, the intruding or input charge launched from a distance will cause an internal explosion. Generally, it involves large-scale damage, blockage of escape routes, smoke and fire. These cases originate from the so-called asymmetric warfare, instead of symmetrical warfare, and pose a problem to the safety of protected facilities.

Grouping of offensive weapons by their destructive effects

The supporting structure designer should design the protected facilities against *offensive weapons creating shock wave (and suction effect)* against a support structure. During the

[7] For instance, the TOMAHAWK guided missile system in service at US Army.

[8] For instance, in the case of a facility in Yemen, designed and constructed by Hungarian engineers and constructors, respectively, which was attached quite soon after the handover

[9] An internally launched weapon, delivered into the building and exploding there.

detonation, very large front-pressure waves arise (deformation thrust at obstacles) in the surrounding environment. The delimiting structures of facilities are generated by tensions, to which they must respond. After the pressure wave, also a so-called suction effect can take place, with a lower intensity than the former. In addition to the shock wave, other special effects may also occur.

Figure 10: Impacts caused by explosion [6]

Weapons generating electromagnetic impulse (EMI) amplify the targeted electromagnetic radiation of nuclear weapons. Every advanced army lays a great emphasis on its development. They do not pose a threat to living organisms, but they permanently ruin electrical devices. [3; pp. 82-86.] The most effective protection is the protective layer or the Faraday cage against them.[10] This can be tackled by special means (e.g. by sparking).[11] [1]The point is that they are capable of detecting very high (even greater than solar) intensity light emitted by a device and then creating an electrically-free, so-called, zero mode in the entire facility. If this is not available, full sheltering must be used for protection and, at the same time, with adequate protective layers. There are types of weapons that are also dangerous to living organisms.

Nowadays, *weapons emitting toxic gases*, including asymmetric warfare, can be one of the most effective tools against specially fortified facilities. Weapons that emit colorless, odorless poisonous gases placed at external surface contact points (such as air intakes) can pose a significant risk. If the system does not detect and the filters for not performing their task, it may be fatal to those inside. This weapon can be produced in a simple way, at a low cost. The most dangerous are the colorless, odorless gases.

Aerosol weapons (releasing igniting and explosive gases) can be produced at a low cost, just as easily and quickly as toxic gases. They can also be delivered at the surface contact points. They pose a similarly high risk to those inside as toxic gases. Of course, in general, they are also colorless and odorless. By forming a suitable explosive mixture with air, being igniting, the can result in complete internal destruction. The most effective protection against them is the so-called sparking. At the air intake points, after detection (or continuously) sparking must be carried out, which, before suction, ignites and combusts such mixtures. Weapons that emit such gases can endanger not only living organisms, but the built-in instruments or devices and machines inside them.

The group of *contact destructive weapons* include weapons that can effectively destroy a local target. Specially fortified facilities always have external, surface appearances and structures. They can be effectively attacked with contact destructive weapons. They may be delivered in several ways.

[10] Faraday cage: Part of space surrounded by a metallic mesh to eliminate the electromagnetic effect, into which the outer electric force field does not penetrate ("shielding") due to the protective effect of the mesh. This can explain, for example, that in buildings made of reinforced concrete structure, there is usually no field intensity for mobile phones to function.

[11] Based the verbal comments by Dr. Horváth, Tibor.

Human factors

One of the most common issues that emerge from the first steps in design is the *definition of an incorrect, incomplete system of requirements*. Unfortunately, in Hungary as well, it often happened that the investor was unable to provide adequate data. Many people do not even think, but even during the design of a specially fortified facility, the criteria set by an investor or by professionals commissioned by it, generally, should contain quite a complex set of information, deliberation and probability calculation. If they are determined incorrectly by the designer, the facility may not provide adequate protection against certain effects. Conversely, the construction and the operation of a facility will be uneconomical. The problem is not simple, because the offensive weapons of the future have to be ascertained, their nature, duration and the effects of an attack should be forecast. Unfortunately, in Hungary as well, it often happens that an investor is unable to provide adequate data. There is a common case that, incorrectly, risks are only investigated at the time of construction and not for the duration of expected lifetime. Additional conditions are required to create facilities.

The professional and high-level design of these facilities can only be carried out by highly trained engineers with special knowledge.[12] In summary, if it is missing, it is called *incorrect and wrong design*. For example, details, seemingly small, should be taken into account by the designer like the proper attachment of fixtures. If this does not happen, the shock wave on the facility may cause acceleration to these objects, which, during their displacement, may cause even mass casualties or serious injuries to the personnel inside. For example, a raised floor designed and constructed in some of the premises of the Air Command and Control Center of the Hungarian Defense Forces (HDF) in Veszprém. Its short but dense pillars, in case of a shock wave, may cause serious injury to the persons inside as a result of tripping. Today, designing or transforming, modernizing a new protected facility would be a serious concern, as professionals with such experience have already retired or died. There has not been any training of designers of these special impacts for decades in Hungary. In addition to designing, implementation can entail risks as well.

Incorrect and wrong construction can also be a risk factor. Although the technical solutions of these facilities have been implemented and checked by technical inspectors according to much stricter rules than the average. Still, some solutions were made to different (lower) standards, for example, due to the incorrect selection of materials and technology. They can be such that have only become known during construction, or others that may cause issues in the long run. To maintain these facilities, regulations and procedures different from the conventional ones are required.

[12] See the designer team of such facilities built in the past: for example, a former designer team of the Road and Railways Designing Office (UVATERV), designer company, which designed a part of the Hungarian facilities, including the reconstruction of the KAGRA facility under the Buda Castle, or the specially qualified engineers of the HDF Building Designer Institute (ÉPTI Kft.).

Figure 11: Tunnel lining wall incorrectly constructed (and consequently, deteriorated insulation) in a KAGRA (Kamioka Gravitational Wave Detector) facility in Budapest[13]

In specially fortified facilities, quite complex and complicated mechanical systems operate. Therefore, the *lack of qualifications and the inability of the operating personnel* are unacceptable either. Maintenance workers and operator specialists, used to normal buildings, are not able to operate such facilities. Generally, this job requires the learning of special methods and time. In theory, appropriate specialists should be selected to perform these tasks, which used to happen earlier in Hungary. (Typically and intelligibly, reliability was very important in these jobs.)[14] The task of the operating personnel is to maintain the facility and assets contained therein, to provide its operability and to carry out planned preventive maintenance. If an operator cannot make decisions quickly and efficiently, it can seriously jeopardize the personnel inside and even the entire building. A no longer classified facility in Budapest today is a good example; a small electric fire broke out, to lead away the large smoke generated from which, a member of the operating personnel made a wrong decision and opened a wrong shut-off door, and thus circulated the smoke back, creating an even worse situation for the staff inside.[15] Regular retraining and national security vetting of the operational personnel are also required.

The access control in these facilities is quite strict, done under highly classified rules, therefore, *unauthorized physical intrusion* should be prevented in any case. This group includes organized attack of combatant units, accidental intrusion by an alien, the appearance of the fleeing civilian population or terrorist attack. In these facilities, during access control, after the preliminary check, the identity of a person is checked; the number and type of objects to be taken inside is restricted, otherwise, in case of an unauthorized intrusion, the operators and the personnel inside would be severely endangered. Although it is usually difficult to implement at such facilities, it still has great dangers. There are several facilities in Europe, which, due to their location in great depths would be difficult to threaten efficiently with offensive weapons, however, after intruding, significant damage could be caused to them. Thus, an installation can be easily made fully non-operational. To be able to intrude, of course, its location, design and physical parameters of the facility, of course, should be well known, that means intelligence

[13] Photo by the author in 2015.

[14] Based on stories told by the operational personnel of some of such facilities still operating.

[15] Verbal comments by Steyer, Ferenc on the events at the shelter at Budapest, Uri utca 72. (former National and Budapest Load Distribution Center).

should work at a high level. Because people's minds and actions are sometimes difficult to calculate, efforts must be made to prepare for the following threatening effects. This risk factor can be avoided by the professional design of external protection defense lines. Generally, they are physical obstacles, monitoring, warning and alert systems or the combination thereof. [11; pp. 67-71.]

Though quite rare, *revenge and sabotage* are also possible risk factors. It is the entirety of acts in the case of the detriment of one or several people that may lead to an act threatening the safety and security of the facility. Though quite rare, revenge and sabotage are also potential risk factors. It is the entirety of acts in the case of the detriment of one or more people who may lead to an act threatening the safety and security of the facility. It may happen by disclosing information or in damaging. Sabotage differs from revenge to an extent that it does not usually occur because of its own detriment, but due to external effect (intimidation, political motivation). It is so rare that it has records in Hungary, although the perpetrator would have had to face serious sanctions.

Bribery, industrial espionage and extortion are similar to the above, but there is an external motivation for influence or financial support. This is also a small risk factor due to vetted persons. However, there were several examples of industrial espionage already in Hungary. There was an event when the chief mechanical engineer of a large designing institute defected Hungary and revealed the parameters of a very important facility to the host country's counter intelligence.[16] In order to avoid such and similar cases, only people with security vetting were admitted to the specially fortified facilities in Hungary, monitored and for more than half a year. With them, such risk factors could be minimized.

In Hungary (contrary to the practice of some other nations), during all political regimes, there was a common position that specially fortified facilities should be protected by classifying them. The main reason for this comes from their function. In addition, one of the goals is to completely hide the data before the enemy, or in peacetime and in special legal order, to avoid the significant exhaustion of the physical personnel in keeping the population away from the facility. (A note by the author, if there were enough shelter capacity in Hungary, such a risk would not emerge.) As a result of reconnaissance and gathering intelligence by other nations, due to frequent superficial confidentiality initiatives, they are quite aware of such facilities. One good example is that, in Hungary, the British intelligence had reliable and detailed information on the so-called P50 facility (named KAGRA today), significantly upgraded and reconstructed in 1951 and 1952, already during its construction. Their findings were released during the Hungarian night program of the BBC Radio broadcast in Hungary.[17] Therefore, secrecy and encryption should have priority and considerable attention. Another typical example is the defectors, who were found by alien intelligence agencies and much information was gathered from them. A good example is the defection of the already mentioned chief engineer György Straub from UVATERV in 1966, where, besides many others, the largest and most secure facilities were designed.[18] In addition, civil servant Kálmán Mészáros, defected in 1979, who, as a driver, knew about a Budapest facility. Counterintelligence service collected operational data on him that allegedly had been contacted by the US intelligence agencies and then he revealed all the data he knew. [12]

A facility, on which foreign services have little information is very rare, so, the exact location of the facility was almost always and is quite well known. It is common that these facilities, due to cost reduction, utilize and expand already existing facilities. For example, the location

[16] Verbal comments by engineer Dr. Müller, Miklós (BME, Department of Geotechnology), also confirmed by historian Ungváry, Krisztián in connection with one of the former chief designer engineer of designer company UVATERV.

[17] Based on the notes taken during the enlargement of the then Facility P50 under the Buda Castle. (Stored and safeguarded: KAGRA design storage room T3f1)

[18] Verbal information by engineer Dr. Müller, Miklós (BME)

of the largest protected command post of the Federal Republic of Germany (FRG) was known by the Soviet Union, since the precise list of underground facilities of the Third Reich is complete, with the exact site locations being available to them. Since the protected command and control center of FRG was built utilizing and expanding such a facility, the enemy was able to locate it all the way. [13] There are some countries (mostly Scandinavian countries) where the location of protected facilities and even other important data are openly accessible to anyone. In these countries, due to the local culture and based on the large number of residential shelters, it is understandable. Classification before World War II, during the Horthy period, was merely the vetting and control of designers, construction contractors and workers and by having to sign a declaration. During the Cold War, this was taken much more seriously. At this time, design of such facilities took place in confined spaces within closed offices. The participants would work in intimidation and under pressure. In the post-communist regime period, not even the specialists knew how to deal with this information: new legislation was waiting to be adopted for a long time. Nowadays, several facilities have already been declassified. Knowing the past, this was wrong, as they still are likely to be needed. If needed to build new ones, neither time nor resources could not be ensured, because to design and construct them would take considerable time and/or money. A decision should be made now and not when it would be too late. This can be ensured through the correct national security policy.

Figure 12: The construction of the largest protected command post of the Federal Republic of Germany in the 1970s [14]

Although it is not typical and represents a low level of risk compared to others, it is worth mentioning *violation of rules and indiscipline*. Operational personnel working in specially fortified facilities have strict operational safety and protection regulations. In some cases (mainly in the deployment period), their violation may entail risks. For example, failure to perform planned preventive maintenance (TMK), the commissioning of certain machines and devices can be questioned. For example, inappropriate handling of radioactive materials kept for chemical protection devices can cause significant health problems.

Unauthorized intrusion into the control system is perhaps less threatening. It happens from the fact that facilities still operating in Hungary are outdated at a level that their control systems, even if they wanted to, could not be linked up to the system's external security telemonitoring system (e.g., the Internet). Another reason that *unauthorized remote cyber intrusion* does not represent a risk, is because the facilities are provided with independent internal building operational management. However, some of the cyber attacks do not require internet connectivity, and malicious codes can be transmitted with the help of an intermediary system -

consciously or negligently, the electronic environment serving operation becomes vulnerable as well. This attack may target the microcoding of the internal control of some systems and devices (firmware). The exposure of facilities to cyber attack is not necessarily based on the existence of the most up-to-date computing devices.

Today, there is a basic requirement for a building operational management and control system to be complex, "intelligent" and independent. It could be a serious threat to a new facility if there were a living external relationship with the outside world. In case a professional hacker intrudes, they can take your entire system under control, or cause serious damages deliberately. If such a facility were upgraded, the building operations management system should not be connected to external communication, and one should set up protection against an internal attack.

The *lack of documentation for the operation* is a non-typical error source. Deficiencies in the documentation that are described in detail in the documentation for the operators are revealed over time and need to be replaced. They can be bridged with improvisation by appropriate operating engineers and specialists. In the long term, improvement and supplementation may take place. It poses a risk if the facility is forced into a live operation immediately after its handover and there is no experience and time required for operation. nfortunately, in Hungary, after a rapid construction of such facilities, frequent belated decisions on the construction occurred in great numbers.[19]

In today's environment in Hungary, one of the risk factors inherent in most of the dangers is *improper or poor maintenance*. Among our facilities, especially during World War II and the Cold War, the danger of closing most of them had been raised already. In most cases, they do not have a function. That is why the political leadership treats them as a “stepchild”. Sometimes they see ideology in an old system, though this is a misconception, since all democratic nations had built similar ones as well. There are no resources to maintain (and renovate) them. The main reason is that financial expenditures will not be visible and, therefore, cannot be used for campaign goals. Because their professional closure that would comfort the environment protection experts, would generally absorb much larger amounts of money than their many decades of operation, they are maintained at a basic level.[20] The closure of one of the high-security facilities a few years ago in Hungary would have cost as much as its operation, on the present very low technical level, for approx. 300 years. Of course, this would be a time, besides desirable operation and maintenance, "only" approx. 30 years. Not even mentioning the fact that the amounts invested so far and the existing asset value would be lost for the nation at termination. It is clear that closure is not profitable. Even in this case, its good security policy of a nation would be decisive.

Underground protected facilities, for obvious reasons, can only provide a very confined living space for the personnel inside, especially after longer stays, the *psychic exhaustion and disruption of the staff inside* may happen even in large numbers. Though its appearance and treatment can significantly be extended today with medication, it still has a major source of danger, since the recognition and handling of perpetrators as dangerous individuals is complicated. Even before the problem is detected, it can trigger an action (for example, the unauthorized opening of a shutoff door) that could endanger the lives of the entire staff inside.

[19] For instance, the World War II period, when they was not enough time to complete some facilities like in the Buda Castle.

[20] For instance, based on the cost estimation of the proper occlusion of the largest highly protected facility in Hungary.

Figure 13: Protective door corroded due to the absence of maintenance in the KAGRA facility[21]

Living conditions

In specially fortified facilities, a basic requirement is that one should be able to shelter from the outside world for a shorter or longer time. The basic living conditions must be ensured for those inside. For humans, the condition "consumed" in the largest quantities and thus diminishing generally in the shortest time is air (mainly the oxygen within it). Therefore, one of the most serious risk factors is the *lack of adequate oxygen*. Under 16.25% of the oxygen content of the air, significant fatigue and the risk of fainting prevails, while at 14%, life is at risk. Filters, ventilation and air conditioning equipment and oxygen reserves can ensure these facilities the required air supply and composition. The systems must be equipped with carbon dioxide absorbers as well. In one facility in Hungary, during a deployment exercise, the oxygen content of the air decreased to a value that one could not even light a match.

Figure 14: Oxygen bottles in an ex KAGRA command post[22]

[21] Photo by the author in 2015.
[22] Photo by the author in 2011.

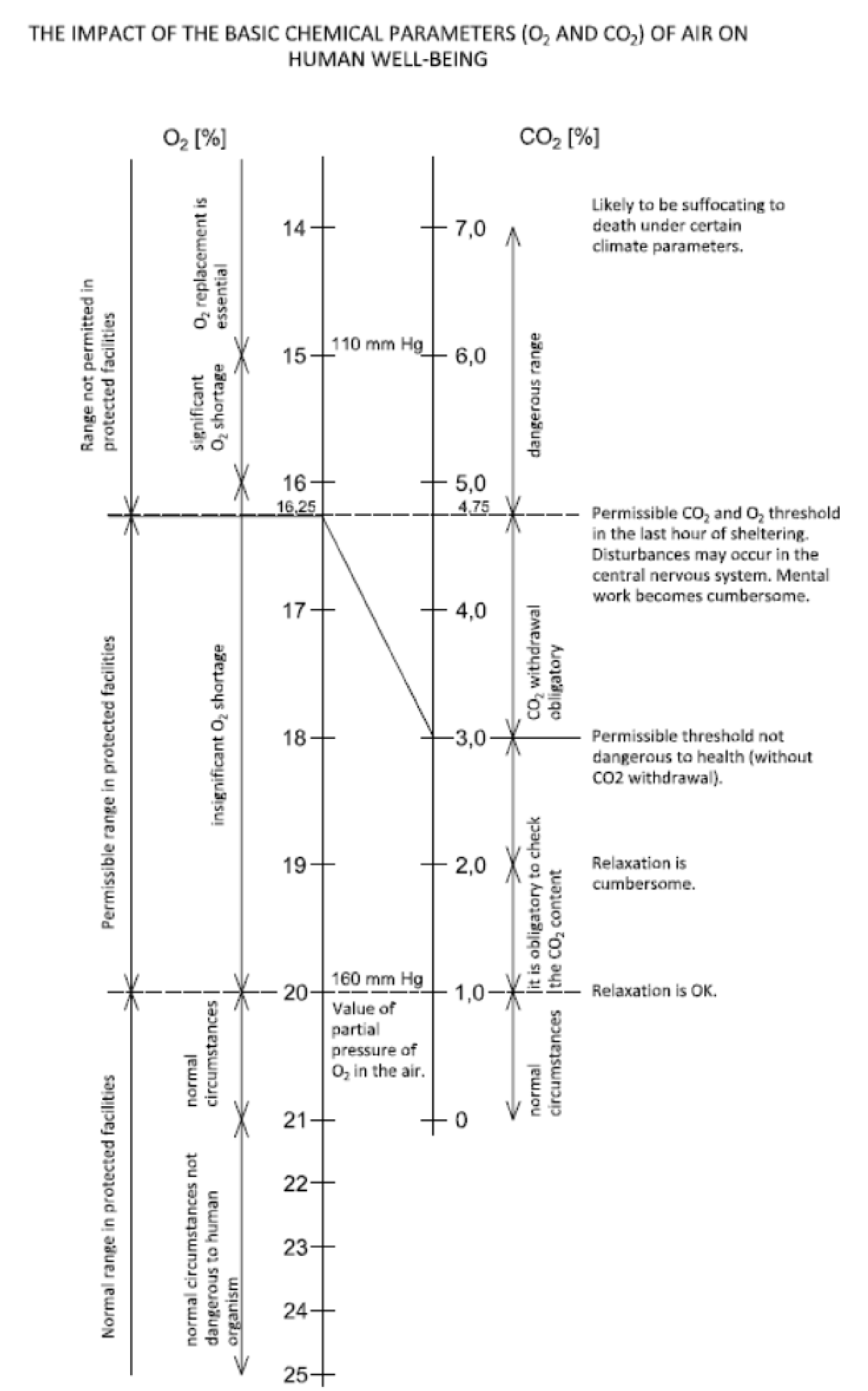


Figure 15: The effect of the content of oxygen and carbon dioxide of the air on the well-being of humans[23]

For humans, after air, drinking water is the most necessary living precondition. So, the next life condition risk factor is the lack of drinking water. Generally, survival time due to the lack of drinking water can be measured in days. In such facilities, water is not only needed for drinking, cooking or washing (including the operation of WCs), but also to operate machines

[23] Made by the author based on the document received from the operators of the KAGRA facility. A credit goes to them.

and equipment. Not even mentioning the water supply of medical points (or hospital detachments).[24] Several machines cannot operate for extended periods of time without cooling water. Generally, refrigerators and air conditioners also require a large amount of industrial water. As a result, in facilities with higher protection capacity, own water sources are at hand or they large enclosed and protected reservoir.[25]

Figure 16: Reinforced concrete drinking water container in the Hospital in the Rock in Budapest[26]

An obvious condition to be provided to humans is *food* in facilities suitable for long-term stay. In World War II, at numerous shelters, masses (mainly infants, babies) died of starvation not due to other effects but simply because of the lack of food. In these facilities, there is a need to accumulate long shelf life foods in larger quantities.

Specially fortified facilities, in any case, have at least two independent (one main and one backup) power supplies. Generally, the primary one is the external power supply, while the backup source is the internal power supply that is ensured, for simplicity, usually with diesel power generators. Without energy, the most basic systems (for example), ventilation systems would not be operational. Therefore, the *lack of fuel* can cause serious disruption. During World War II, the Capital's Surgical Hospital (nowadays called Hospital in the Rock) under the Buda Castle, due to the lack of a backup power generator (diesel) induced a very serious situation. Out of the two built-in machinery groups, one was taken away by the intruding Soviet troops. With this, the hospital could not satisfy its most basic needs and the quality of overheated internal air quickly became critical.

Since power generators are able to operate exclusively with fuel (and lubricating oil), they need to be looked after. Fuel (diesel oil) is generally provided from storage units in a protected location for different time periods.

[24] In WW II, in the Capital's Surgical Emergency Hospital, under the Buda Castle, nowadays called the Hospital in the Rock), lack of water created a serious situation. There was not enough of it even for drinking, not to mention other basic tasks. Therefore, a hydrological engineering building and a long pipeline was constructed during the cold war at one of the Danube bank water outtake plant.

[25] For instance, in the KAGRA F-4 facility and in the Hospital in the Rock.

[26] Photo by the author in 2003.

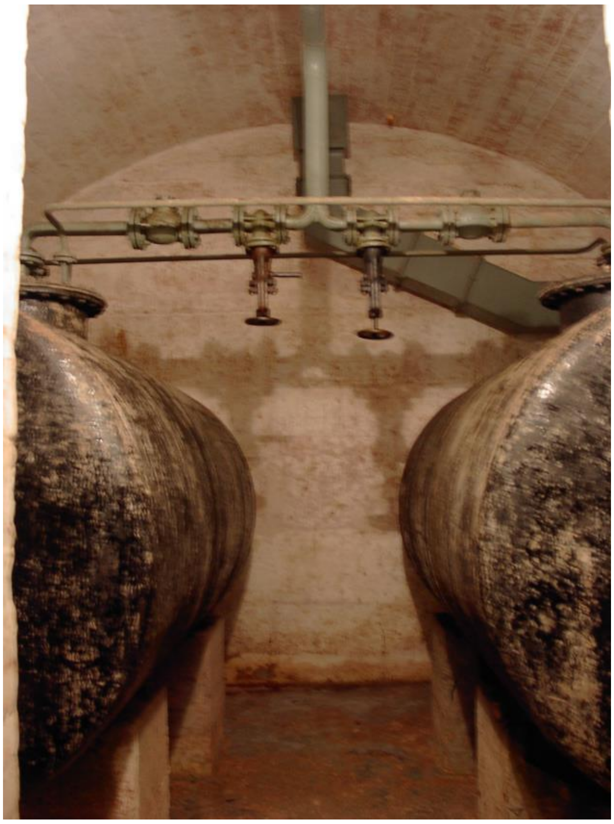


Figure 17: Fuel tanks in the Hospital in the Rock in Budapest[27]

Figure 18: Power generator in the Budapest metro line [15]

From the aspect of operation, one of the most critical issues is *overheating*. For most facilities, there is a significant problem despite the fact that in Hungary, a constant temperature (about 11°C) around the annual mean temperature can be measured. In the case of specially fortified facilities operating for a long time, or previously equipped with heating, a heat shield (heat coat) has formed in the rock environment from internal waste heat over the decades, which kept the indoor temperature of the facilities at very high. So, after the deployment, the internal temperature may rise rapidly to the permissible and tolerable level. This caused serious

[27] Photo by the author in 2003.

problems for several facilities. One of them was at a government shelter[28] and nowadays, in metro line M3 in Budapest, it is a considerable problem[29]. There can be an effective protection that in the maintenance (pre-deployment) period special care is dedicated in these facilities to keep the internal temperature below 16-18°C if possible. This can be ensured by switching off the internal consumers and/or with constant cooling.

Since protected facilities are generally in use in non-peacetime, the likelihood is great that non-healthy (injured, wounded) personnel would use them. Adequate *healthcare conditions* are to be ensured for the personnel inside. For example, the lack of medical care, medical instruments, medicine, disinfectants can develop a serious internal situation. For example, a simple influenza rapidly spreading in such enclosed spaces can paralyze the entire operation of the facility. It is imperative to form a hermetic separator room. Additionally, it is important to address the issues of temporary storage and handling, dispatch of biological contaminants and corpses.

Natural impacts

Earthquakes have a lesser detrimental impact, as the facilities are also safe against shockwaves from significant explosions, so they can withstand earthquakes with very similar efficiency. There is no facility in Hungary constructed on a system of internal absorbers, the protection of only some built-in devices is solved in this, in certain places. In contrast, in the case of protected facilities built in an environment that is seismologically more active and geologically unstable, this can be an important factor.

Floods and tsunamis are also less dangerous because the facilities were or are built in generally non-floodplain locations. If necessary though, the shutoff doors (if shut) will fully withstand the water pressure due to the load. For instance, one good example is the protected command post, the F-4 facility, underneath the Inner City in Pest, built for MDP, in the middle of the 1950s. [16] Tsunami in Hungary is absolutely excluded.

Lightning is also less dangerous because these facilities are protected against electromagnetic impulses, including lightning, as they are usually located underground, so the protection is enhanced.

The natural formation of *wild fires* is possible in rare cases (due to fierce, long-term, large spatial lightning or volcanic eruptions), but in our case, we understand extensive long-term and high-temperature fires after an atomic bomb explosion or the ignition by other bombs inducing high temperatures in large areas. They are characterized by extremely low oxygen levels, strong suction and toxic gases. According to the design specifications, one should calculate with a 48-hour duration and a 2000-degree Centigrade gaseous temperature. Of course, the use of external air intakes is not recommended during this period. If it becomes necessary, however, a significant reduction in the temperature of the gas, cleaning and filtration may become necessary as well. It is extremely dangerous, because a significant part of facilities in Hungary is built on an easily combustible, densely forested area.

Where appropriate, due to *geological and hydrogeological changes* or due to changes in other human activities (e.g. deforestation, quarries, etc.), the solidity indicators of the supporting rocks may change, soil slides may occur and the water output of the inner wells may dwindle. This is a lesser risk because the existing facilities are located in enclosed areas, so, in principle no harmful deforestation or destruction may occur.

[28] In the 90s, in Warehouse IV of MoD (nowadays called KAGRA), a restricted government session with a small number of attendees was held; the facility overheated itself in a short time despite mechanical cooling.

[29] The Budapest metro line M3 nowadays, due to its normal operational heat release would already have too high temperatures even before deployment. The author's own observation during a sector test in 2016.

Other impacts

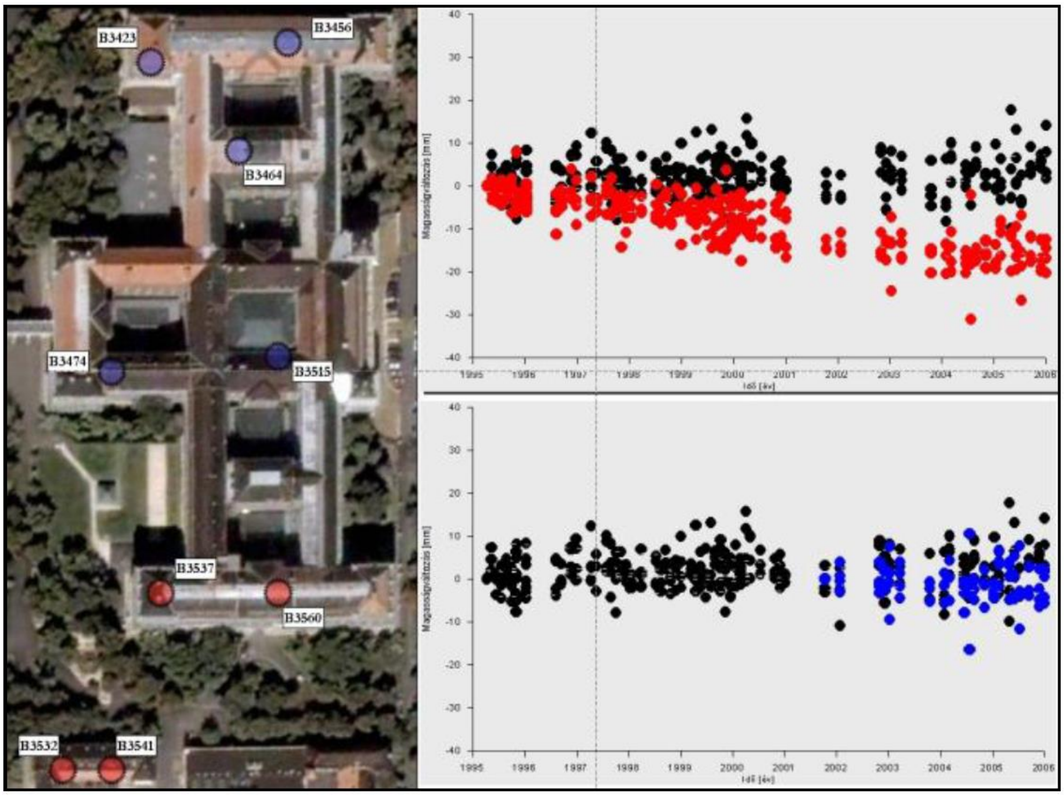
Because of the advanced industrial production by mankind, a protected facility may be built near a chemical or industrial plant. It is also possible that it is located further away, but in case a large *industrial or chemical disaster*, it becomes involved. This is possible, for example, due to the eventual failure of two Slovak nuclear power plants near the Hungarian border. In such a case, the devices built in against other effects (filtering and ventilation systems, locking ability, etc.) would provide sufficient protection in general.

Perhaps one of the most damaging effects are posed by *internal fires*. This is because these facilities always consist of narrow and confined rooms. Their (emergency) exit corridors are usually hundreds of meters long. The smoke emerging as the side effect of fires can cause very significant problems. A good example is the fire tricking even professional firefighters, equipped with oxygen cylinders, through corridors under the labyrinthine basement of the Budapest University of Technology and Economics (taking death tolls), broken out in 2006.

Generally, *operational disruption* is a system process based on a domino effect, resulting from some sort of anomaly. Nowadays, it poses an increasing risk because electronic control systems (building operational management systems) are more and more complicated and the interaction of some systems is not always known satisfactorily. By testing, practicing and simulating, the effects can be significantly reduced.

In specially fortified facilities, there are numerous hazardous devices, machines or equipment in service such as switchboards, batteries, diesel power generators, fuel tanks, oxygen bottles, compressed air containers, etc. Improper handling of them can cause an internal explosion as well. Complying with the rules, risks can be minimized. In fact, the use of conventional explosives in a confined is not a negligible factor besides heat and the shock wave of the explosion, neither is the resulting lack of oxygen and the toxic, choking effect of the residual gunpowder.

The *ever-accelerating technical development* is a major threat to a well-camouflaged, protected facility. This is a very good example of a new technology, the so-called satellite radar interferometry technology. Its essence is that some satellites, since the end of 1992, continuously emit radar signals and measure their reflected data. Signals can be reflected from any solid and large objects (building, pavement, ground). Satellites emit radar signals to all the points of the Earth (except the seas, oceans) with very high density, in an unprecedented resolution (up to 500-1000 points/km^2). The measurement is so accurate that it detect an approx. 0.1 mm/year vertical movement. No field measurements are required. The results of the measurements have been saved retrospectively for decades, and some of them can be retrieved for civilians and researchers as well. [17] [18; pp.3-9.] Obviously, it is possible to write automatic registration and signaling programs for these sets of data that monitor and indicate the major field movements for the human analysis service. As a protected facility, almost all built with mining technology, with the surface collapsing, it is almost impossible to conceal a new (or built since the early 90's) underground facility.



119: The timelines of sprinkle points are marked with black, located in the central and northern part of Building K of BUTE. Marked with grey are the timelines of the sprinkle points of the southern part and the immediate neighboring buildings. In the lower figure, marked with grey, you can find the data for the same after the reinforcement works of the base [18; p.8.]

Over the past decades, the efficiency, capabilities and capacities of reconnaissance have increased tremendously. Especially due to the widespread use of technical detection, there are far greater opportunities inherent in what the contemporary concealment and disguise of these facilities would provide. It can be stated that similar facilities in the world are generally well-known by foreign intelligence services and by the local population as well. This is partly so, as nowadays, with the rapid development of the technical level of these facilities, camouflaging solutions of these facilities have not at all been kept up-to-date. Therefore, the *lack of camouflaging* is one of the greatest risk factors. Today, due to the precision and the details of visual or satellite reconnaissance, a surface construction cannot be concealed. An underground construction would always have a surface “footprint”.

Changes in the national defense policy and the willingness of the current government to allocate financial means is the factor that nowadays mostly determines the present and the future of such and similar facilities. Leaders (of current national governments) do not take into account that domestic or international environment and the national defense policy [19; pp. 113-118.] [30] can radically change in much less time than the lifetime of such a facility, or even the design or construction time. So, there is a need to create, maintain, operate, close, or dispose of these facilities to meet the current circumstances, to avoid the worst outcome. Nowadays, Hungary does not have an enemy concept; therefore, most of these facilities were abandoned or left entirely to decay in the past decades. In other (Western European) countries, where the extent of external threats is similar or perhaps even more favorable, these facilities are still maintained and operated at a high level. The situation in Hungary is well characterized by the fact that some years ago, politicians had brought up the closure of one of the highly protected facilities, which could have served as shelter for them in a classified period. This "idea" was

[30]An earlier article on the relationship between national defense policy and shelters.

not implemented just because the proper closure (occlusion) of the facility would have cost a huge sum.

Communication nowadays in all the fields is essential. There is a need to keep in touch with the rest of the world. Much of this work is exposed to data traffic inward and outward. As these facilities are generally large in size, communication between the internal departments is also important for security reasons. As a result, the *lack of external and/or internal communication* may be a cardinal issue. The following figure shows an older communications center.

Figure 20: Communications center of command post D0 (code name Istanbul) in the former Yugoslavia (nowadays Bosnia-Herzegovina) [20]

RECOMMENDATIONS ON THE PROTECTION AGAINST ENDANGERING FACTORS

Protection against offensive weapons is paramount with these. One may and should protected against them with a suitable thickness of protective layer and masonry as well as doors and windows. It is possible to protect against high dynamic effects with so-called absorbers[31].
Against EMI, it is possible to protect with proper structural thickness, steel lining and multilayer construction.

The threatening effects and factors need to be known to establish and maintain specially fortified facilities, which are necessary for the correct establishment of requirements. Their analysis and risk assessment must be carried out before the design phase.

During the design and construction, only the highest qualified, experienced and certified engineers can be employed. Training must be continually maintained. Design faults can be screened by employing design controllers.

Training of the operating personnel is just as well needed as the one of designers.

Against physical intrusion, protection can usually be ensured by complex, intrusion-protected solutions. There are countless devices to protect against unauthorized intrusion. They can be physical, optical, visual, electronic solutions. Other special solutions used are infra-red cameras, motion detectors and gas-tight protection doors. In some places, a very simple method is used: the sand in the vicinity of fences is raked in a special pattern, in which the footprints of an intruder become visible.

[31] Absorbers are energy absorbing and energy conversion devices. With their use, the physical impacts on structures can be moderated. For example, springs to which diesel engine groups are mounted.

Preventing malicious data acquisition is nowadays a very difficult and complex task. For example, when constructing a new facility, much attention should be paid to the fact that mobile phones at the workers, well-known by foreign intelligence, should be made inoperative before any meeting, especially when traveling to the site, as mobile telephone operators in foreign hands can easily obtain important information with these devices.[32]

The psychic exhaustion of the personnel inside can be prevented through more livable and friendlier interiors (for instance calming, warm-colored walls[33], recreation rooms with dead windows covered with curtains[34], etc.), with proper behavior and monitoring network and sabotage-proof structure design (for instance delimitation).

Of course, when constructing new building operational management systems, it is not advisable to connect them to external networks. It is advisable to create a physically completely separate network and to provide access only from the internal dispatcher room.

The biggest challenge is fighting the ever-accelerating detection and intelligence techniques. For example, against satellite radar interferometry one can protect with dense vegetation cover, as signals are not reflected to satellites.

Fuel (energy) can nowadays be produced with advanced technology, in other ways (e.g. from geothermal sources, thermal water, etc.), but they are not yet widespread systems, and since the construction of a new facility is not on the agenda, no such systems are built.

SUMMARY

From the above it turned out that, from design to operation, the definition of requirements is a very complicated and complex task at such a facility. They should be incorporated into operational plans as well. Thus, risks can be minimized. The probability of occurrence of the above effects should always be determined individually. One should be aware of the need to develop a level of protection. Unfortunately, due to the complexity of probability calculation, it is often not done. One can prepare them for an effect at one time, relatively easily and effectively, but the coexistence of two or more unfavorable factors can result in a very high risk level. For example, the appearances of a serious construction failure and an offensive weapon triggering shockwave. Or the simultaneous extortion and the introduction of toxic gases at any surface connection point.

Protected facilities should be dimensioned and designed to face a number of risk factors, requiring very special expertise. Recent and present politics regarded them as almost "unnecessary". Future natural and political challenges recognized, however, the necessity of these facilities. The present and future utilization of the existing ones are dealt with by some specialists on research level as well. [21; pp.296-310.] Ferenc Kovács and János Szalai could be mentioned as such examples.

Overall, it can be stated that protected facilities deserve more attention within the defense/protection sphere; and the exploration of endangering factors is the basis of any further activity.

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[32] Dr. Horváth, Tibor called my attention to it, special thanks to him.

[33] Guidance by Potucsek, Iván during the reconstruction of the HDF Air Command and Control Center in Veszprém.

[34] An example of such settings is the recreation room of the Kingsway underground telephone switchboard center under London City.

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