Impact of the lining of mining galleries’ technical condition on the safety of mining crews

P Mocek
Silesian University of Technology, Faculty of Mining and Geology, 2 Akademicka Street, 44-100 Gliwice, Poland
E-mail: piotr.mocek@polsl.pl

Abstract. The article deals with the issues related to the impact of the technical condition of the mining gallery: preparatory, near-wall, main (transport) and ventilation for the safety of mine crews working underground. The author presents an accidental statistics of recent years in underground mining, with particular emphasis on events arising as a result of a rock burst, a collapse, fall of rocks from the roof and the side wall. He describes the current legal status in the field of infarct danger, fall of rocks from the roof and side walls as well as selection and control of the frame support. Control methods of the condition of support of underground workings have been described and attention has been drawn to the fact that the visual method used by most mines to assess the condition of the corridor workings is insufficient due to the safety of working underground.

1. Introduction
In the hard coal mining industry accidents, including fatal and heavy accidents, have often occurred in recent years as a result of bumps, collapse or fall of rocks from the roof and side of works. Apart from natural phenomena caused by concentration of stresses in rock mass during preparatory and exploitation processes causing rock burst or shock, accidents are also more often caused by loss of excavation resistance due to poor condition of its frame support. Such situation usually occurs in the so-called old workings in which the frame support was made in the 80's and 90's or even earlier and is caused by the most often progressive process of corrosion of steel elements of the flagstones or its deformation as a result of conducted operations. In the recent period we have also dealt with accidents caused by improper steel arch support lining in hollow workings or structural defects of the friction shield.

As it turns out in the course of post-accident proceedings conducted by the mining supervisory authorities of WUG and OUG, many of these accidents could be avoided if the man, control systems and the "father" of most mining problems were not let down - economic calculus. It turns out that Polish mines and mining plants have a well-prepared paper technical documentation, developed procedures and technologies as well as executive instructions that meet the requirements of applicable mining regulations, but their implementation and compliance leaves a lot to be desired and is often explained by enforced financial savings and priority actions. Therefore, in the conditions of not only the Polish mining industry, we postpone it "for tomorrow", which happens to be very distant in time, and the consequences of such action are incidents as well as heavy and fatal accidents that start to surprise us today. This article is an attempt to answer the question: How to improve the work safety of mining crews in mining galleries with poor technical condition of the frame support?
2. Analysis of work safety in mining

According to statistics from the Higher Mining Office in Katowice (WUG) [1], the incidence in Polish underground mining for several years, although it has a downward trend, exceeds 2000 accidents per year, which when employing about 91 thousand employees gives 2.2% of injured in accidents. The year 2018 in this statistic should not change much because during its 8 months there were already 1346 accidents, so only 4 less than in the same period of 2017 (1350). The situation regarding the severity of accidents is much worse, because in 9 months of 2018 21 fatal and 14 serious accidents have been reported. Meanwhile, in the entire year 2017 the number of accidents amounted to 15 fatalities and 14 severe ones respectively (table 1).

| Type of accident | Year |
|------------------|------|
|                  | 2014 | 2015 | 2016 | 2017 | 2018 |
| Fatal            | 30   | 19   | 27   | 15   | 21   |
| Severe           | 29   | 12   | 9    | 14   | 14   |
| Other            | 2215 | 2127 | 2038 | 2049 | 1318 |
| Total            | 2274 | 2158 | 2074 | 2078 | 1346 |

Own source

In the years 2014-2016 the reasons for fatal and serious accidents were predominantly mining reasons, i.e.:
- collapses and / or falling rocks from the roof and sides of works;
- dynamic impact of shocks (rock bursts);
- methane ignition.

In the years 2017 - 2018, the dominant causes of fatal and serious accidents were mechanical events, i.e.:
- carrying out works or moving conveyors in motion;
- being in the range of machines and devices;
- impact by horizontal transport equipment.

In the second place of this statistics there appear once more mining-related reasons, i.e. the breakage of rocks from the roof and the side wall, the collapse (29.5%) and rock burst, recovery and rock mass quake (9.8%) (figure 1).

![Figure 1. Main causes of fatal and severe accidents in Polish mining in 2013-2018.](image_url)

Analyzing the collected results, it can also be seen that in the period from January 1, 2014 to December 31, 2018 in underground mining 112 serious events were noted. Most often, as many as 53
times, there were underground fires (53 events), in which minor injuries were suffered only by 2 miners. The situation related to the collapse and fallout of rocks from the roof and the side wall is much worse. In 23 events, death was suffered by 22 people, 16 miners suffered serious injuries, slight injuries were recorded in 944 people (table 2) [1].

Table 2. List of accidents caused by rock burst, shock, collapse and fallout of rocks from the roof and side walls in underground mining plants in 2014-2018 [1].

| Year | Rock burst and shock | Collapse | Fall of rocks from the roof and side walls | Explosion and ignition CH₄ | Fires |
|------|----------------------|----------|--------------------------------------------|-----------------------------|-------|
|      | F        | S        | L | F | S | L | F | S | L | F | S | L | F | S | L | F | S | L | F | S | L |
| 2014 | 1 | 0 | 5 | 0 | 0 | 0 | 5 | 4 | 217 | 5 | 15 | 10 | 1 |
| 2015 | 2 | 0 | 2 | 0 | 0 | 1 | 3 | 3 | 193 | 0 | 0 | 4 | 0 |
| 2016 | 10 | 0 | 39 | 1 | 1 | 1 | 5 | 0 | 219 | 1 | 0 | 0 | 1 |
| 2017 | 0 | 0 | 12 | 0 | 0 | 1 | 4 | 5 | 182 | 0 | 0 | 0 | 0 |
| 2018 | 6 | 0 | 21 | 1 | 0 | 0 | 3 | 3 | 132 | 0 | 0 | 0 | 0 |
| Total | 19 | 0 | 82 | 2 | 1 | 3 | 20 | 15 | 941 | 6 | 15 | 14 | 2 |

F- fatal accident  S- severe accident  L- light accident

As statistics show the reason for these events were human errors, but also:
- failure to comply with the provisions of technical designs and frame support technology;
- uninterrupted, unprotected roof and walls before placing the frame support;
- poor organization of work, e.g. tolerance by persons supervising the work movement despite the improper support condition;
- lack of proper control of the roof and wall before starting work;
- carrying out the removal of the frame support contrary to the instructions
- poor condition of the frame support and its improper control.

Taking into account the above, one can accept the thesis that: the number of accidents in mining, especially those fatal and heavy, should fall if the management of mines and mining plants would pay more attention to the way the mining excavations are made, especially in the workings, and if the mining regulations will include provisions about when the arch support is unfit for further use.

3. Legal basis
Despite the fact that as a result of the collapse and fall of rocks from the roof and sides every year, several hundred accidents, including the most severe ones, collapses and rock fallout are not classified in current regulations of Polish underground mining.

The definition of collapse given in the Ordinance of the Minister of Energy of November 23, 2016 on specific requirements for running underground mining operations only partially brings this phenomenon closer:

"§ 44. 2. The collapse in a mine working is understood as unintentional, gravitational displacement to the mine workings of rock masses or minerals from the roof or side wall to the extent that it is impossible to restore the original function of the excavation in less than 8 hours."

In mining practice, to prevent collapse and crimping of mine workings, a friction or mechanized support frame support is used. The collapse occurs when the periodic pressure of the rock mass exceeds the limits of the casing's strength. In turn, the gravitational precipitation of individual rocks
from the roof or side walls usually occurs during the building of the casing or during its robbing, when part of the rock mass is not supported.

To limit these unfavorable phenomena The Ordinance of the Minister of Energy introduced the restrictions under which [2]:

§ 34.1. Mining works are carried out on the basis of documentation taking into account geological and mining conditions.

§ 38.1. For mining works before commencing: drilling, exploitation, reinforcement, liquidation, - technical designs are developed together with the technology of performing works.

§ 38.2. The technical design shall include in particular: ... the kind and type of frame support ...

§ 38.4. Technical designs and technologies for the performance of works are approved by the mining plant operations manager.

In turn in Chapter 6 " Support and lining of excavations" the principles and conditions for the use, construction, inspection and plugging of the frame support are described. The most important entries in this chapter include:

§ 119.1. The support of the excavation is adapted to the geological and mining conditions.

§ 119.2. The roof shall be protected by the frame support immediately after unveiling, taking into account the applied technology of conducting the works.

§ 120.1. The selection of support and lining in individual excavations is made by the head of the mining department on the basis of: mining and geological conditions; opinion of a university or research institute ..

§ 120.3. Types of support and rules for its implementation are specified in the technical design or technology.

§ 120.4. Persons supervising mining plant operations shall familiarize personnel executing the support with a fixed type of support for a given heading and the manner of its execution.

§ 121.1. The frequency of monitoring the condition of excavation support is determined by the head of the mining department.

§ 121.2. Inspection of the frame support of the main excavations, in particular shafts, inlets to shafts, main transport and ventilation routes, is carried out once a quarter by a person supervising mining plant operations appointed by the mining plant operations manager.

§ 122.1. It is allowed to use the excavation frame support: 1) suspend, raise or move machines, devices and materials, the weight of which will not cause dynamic loads, in particular electric cables with accessories, ventilation pipe with fans and pipelines;

2) lifting, moving and suspending machines, devices and materials that can cause dynamic loads when using: a) ad hoc - provided that an additional reinforcing support is used and obtaining the consent of a mining supervisor, b) permanent - in accordance with the prepared technical documentation after obtaining the consent of the mining department manager.

§ 123. In places unsecured with frame support, it is permissible to stay only for personnel executing temporary or anchor frame support.

§ 124.1. Supporting frame of excavations shall be made in a manner ensuring: 1) protection of the roof lining immediately after its unveiling; 2) its adequate stability and support; 3) filling the space between the frame support and the breach; 4) additional protection against overturning individual lining racks with a height greater than 3 m.

§ 124.2. In case of deterioration of the rock properties or increase of the rock mass pressure, the support frame lining of the excavations is immediately reinforced.

§ 126.1. Rebinding of the frame support shall be carried out in accordance with the instructions approved by the mining plant operations manager.

§ 126.2. The support frame lining removal is performed only by specialized miners.

In spite of these regulations, accidents in recent years show that in underground mining, the system of monitoring the condition of the frame support, as well as its performance and stability, fails.
4. Examples of events related to the collapse and fall of rocks in underground mining

4.1. KWK Ruda in Ruda Śląska, Ruch Halemba
As a result of the loss of stability and resistance of the corroded and not reinforced casing of the roadway supports at various time intervals (figure 2), a roof cavity was found in the ventilation ditch from 525m to 830m, on two sections located from 129m to 135m and from 343m to 355m respectively to the west of the raise area 1 on deck 402. During the works related to the removal of the effects of these collapses, a further collapse was found between 310 m and 318 m west of the raise surface 1 in deck 402. As a result of the collapse, no one was injured, but the work carried out was interrupted for several weeks.

Figure 2. Place of collapse in KWK "Ruda" Ruch Halemba.

4.2. KWK Bobrek-Piekary in Bytom, Ruch Bobrek
As a result of the loss of stability and support of the steel arch of ŁP12 / V32 / 4 / A HL CORR with reduced load capacity from 677kN to 283kN and faulty construction of the lining locks on February 4, 2018 in the research pavement 7 on deck 504 at the level of 726m KWK "Bobrek" occurred a collapse of roof rocks in the excavation. As a result of this event, the locksmith employed in the mining gallery working died on the spot. The reason for this was filling up with rock rubble and elements of the liner for the mechanical coal miner (figure 3).

Figure 3. Place of collapse in KWK "Bobrek-Piekary".
4.3. KWK Mysłowice - Wesoła in Mysłowice
As a result of covering of the excavation roof in the longwall of pavement 588 on deck 501, at the level of 665m on 27/1/2017 there was a displacement from the roof of the rock block excavation, size 1.4x0.4x0.25 m, to the unprotected housing of the frontal zone, in which there were two employees. The falling solid rock led to a collective accident, in which one of the employees suffered minor injuries and the second one was killed on the spot (figure 4).

![Figure 4. Place of collapse in KWK „Mysłowice-Wesola”.

4.4. KWK Piast - Ziemowit in Bieruń, Ruch Ziemowit in Łędziny
As a result of losing the support and stability of the lining, as a result of corrosion of its components on July 24, 2017 there was a detachment and displacement of rock masses from the roof of the chamber of the ZG-1 vertical expansion tank head, built between the belt cross-section 934 C-1, and the ramp from the route of the shaft III (figure 5). According to the findings of WUG, the occurrence of the accident contributed to the failure to reinforce or replace the roof lining of the chamber above the ZG-1 tank, despite the significant corrosion of its components. This was due to the lack or unreliable control of the frame support lining condition by persons designated for that purpose.

![Figure 5. Place of collapse in Piast - Ziemowit in Bieruń, Ruch Ziemowit in Łędziny.](image-url)
5. Methods of mining frame support control

As can be seen from the above-mentioned examples, the correct condition of mine workings is one of the basic guarantors of the safety of mining crews employed underground. Collapse and fall of rocks with which we have the most often in the mining conditions are caused by excessive corroding of the structural elements of the pit support, especially the sliding arches, which have the greatest contact with changing conditions of the aggressive mining environment (water, salinity, chemical compounds, transport elements, electric charges, rock mass pressure). The consequence of these phenomena is a gradual deterioration of the technical condition of the frame support resulting from: durability of the materials used, support profile, operating conditions, quality of workmanship and, most importantly, the service life.

In underground mining, the life of mining excavations depends on their intended use. The shortest are longwall walkways, removed along with the progress of the wall, in which, paradoxically, the pits support is the youngest and the best quality, but it is also exposed most to the changing stresses and pressure of the rock mass. The worse condition of the frame supports is presented in excavation workings such as ditches, crossings and ventilation walkways, in which the life of the supports is often counted in decades. That is why an important element of mining art should be the ongoing monitoring of the technical condition of the frame supports of all mining excavations, because the quality of such control depends not only on the safety of those employed underground, but also on the fluidity of technological processes.

In order to meet these expectations, a group of mining scientists and practitioners created many tools enabling the implementation of § 121 of the Regulation of the Minister of Energy of November 23, 2016 on detailed requirements for the operation of underground mining facilities [3]. The most important methods for assessing the condition of the frame support depending on the type of the parameter being measured can be replaced (figure 6):

- **Geometry research methods** - they are most often used for testing the suitability of mining excavations for use (eg measurements of crimping a mine) and assessment of the condition of the arch support structure (deformation or its individual structural elements),
- **Surface testing methods** - mainly used for testing the condition of the excavation supports (eg corrosion, exfoliations and loss of effort in a masonry or concrete enclosure, etc.)
- **Volumetric research methods** - they are used both in researching the enclosure and surrounding excavation (eg defects-copy of stone support elements, examination of rock mass quality in the vicinity of the excavation - crevice, degree of degradation, etc.) [4].

---

**Figure 6.** Test methods used in the diagnostics of the mining excavations frame support [4].
In professional practice in mining, often under the pressure of management, due to lack of financial possibilities, limited decision-making or simply laziness, we choose the so-called minimalistic solutions (optical methods based on visual tests of the frame support condition), which results look good on paper, but have little in common with the actual state. This situation is especially exposed by accidents and reports from the commission of post-mining mining offices.

6. Practical evaluation of the research topic
In the X mine where the author is the Manager of the Mining Works Department, the assessment of the condition of mining mine workings, especially corridors, has been carried out in two stages for more than 15 years [6]:

Stage I includes a macroscopic assessment of the frame support lining consisting in the determination of the corrosion distribution on the perimeter of the excavation support and the inventory of possible losses in the form of perforations, pits, exfoliations, debris and other surface, it also includes visual defects:

- identification of the size of the arch support and the type of construction elements of the support lining (types of sections, struts, stirrups, type of opinion, etc.)
- assessment of corrosive factors occurring in the tested section of the excavation (rock mass failure, direction of air flow in the excavation, etc.),
- assessment of the construction correctness and the size of the corrosion of the steel arch,
- assessment of the installation correctness and size of corroding stirrups connecting the steel frame support elements,
- assessment of the number, structure correctness and size of the corrosion of the struts and their connections to the arch support,
- assessment of the type and correctness of the support,
- characteristics and assessment of other factors affecting the technical condition of the support lining (estimation of the voids occurring between the frame support and the rock mass, the quality of the bearing of the side wall arches, deformation of the support lining, etc.).

Technical assessment of frame support condition based on visual tests ends with the completion of individual sections of the excavation with the support linings to the appropriate stages:

- S-0: support frame requires reinforcement; "bad condition"
- S-1: support frame does not require reinforcement; "good condition",
- S-2: support frame requires additional tests of the state of strain; "controversial - emergency" condition.

In the case of finding the the S-0 stage on the controlled section of workings the Mining Works Department Manager is immediately informed and determines how to strengthen the arch support.

Stage II of the mining gallery condition control concerns the examination of the condition evaluation of the corroded lining of frame support. The measurements of corrosion degree of frame support elements in this case depend on determining what part of the native material did not corrode. Measurements are made by an indirect, ultrasound method. Ultrasonic thickness gauge by Metrison, model SONO, type M500, inventory number of mine X - 1011 is used to perform these measurements. The measurements are carried out continuously by three technical mining department workers who during each quarter are able to examine the support of all excavations in the mine. This allows for ongoing and permanent monitoring of the strength condition of the arch support.

Before proceeding to the measurements, the surface of the profile wall is appropriately prepared by thoroughly cleaning the corrosion elements and possible impurities accumulating on the surface of the material as a result of its normal operation. After cleaning, the surface is covered with a layer of coupling agent, and then it is measured using an ultrasonic thickness gauge (figure 7).
Measurements of individual steel arch are usually carried out on the right and left side wall arch, usually in three places - at a distance of about 0.5 from the floor (so-called bottom measurement), about 1.8 m (so-called middle measurement) and in the roof of the excavation (the so-called upper measurement). Each time, the wall thickness of the right arm (x), bottom (z) and left arm (y) of the profile (figure 9) is determined. Measurements in a given place are carried out in each of the points at least three times on one line of the section figure 8.

Figure 7. Locations for measuring the degree of corrosion of the arch support lining.

Figure 8. Test stand: B, C, B - test locations on the steel arch support, x, y, z - measuring points on the sides of the support profile.

The thickness measurements carried out on the liquid crystal display of the device are recorded on a specially prepared measuring card (table 2), and then averaged, ignoring the extreme measurements (maximum and minimum). The averaged result refers to the outline of the nominal profile and on this basis calculates the corrosion loss in mm [5].
| Name of excavation | Section | Size of Steel arch | Type of Section | Number of Steel arch | Location of Research | The amount of corrosion loss [mm] | Comments |
|--------------------|---------|--------------------|-----------------|---------------------|---------------------|-------------------------------|----------|
|                    |         |                    |                 |                     |                     | Right side | Bottom | Left side |
| Crosscut           |         |                    |                 |                     |                     |              |        |           |
| Eastern and Western side on 6770 - 6775 km and 6850 - 6851 km sections |         |                    |                 |                     |                     |              |        |           |
| LP-7               | KS/KO21 |                    |                 |                     |                     |              |        |           |
| 1                  |         | D                 | perf.           |                     | 5.4                 | perf. |        |           |
|                    | B       | 4.2               | 4.7             | 1.0                 | 0.7                 |        |        |           |
|                    | C       | 0.8               | 1.0             | 0.7                 |                     |        |        |           |
| 2                  |         | B                 | 1.1             | 2.1                 | 1.0                 |        |        |           |
|                    | C       | 1.5               | 2.1             | 1.0                 |                     |        |        |           |
| 3                  |         | D                 | 0.4             | 2.8                 | 0.4                 |        |        |           |
|                    | C       | 0.1               | 0.2             | 0.2                 |                     |        |        |           |
| 4                  |         | D                 | 1.6             | 2.1                 | 1.1                 |        |        |           |
|                    | C       | 1.5               | 2.3             | 1.1                 |                     |        |        |           |
| 5                  |         | D                 | 0.4             | 0.6                 | 0.5                 |        |        |           |
|                    | B       | 0.4               | 0.6             | 0.5                 |                     |        |        |           |
| 6                  |         | D                 |              perf |                     |          perf | perf   |        |           |
|                    | C       | 0.8               | 1.5             | 1.0                 |                     |        |        |           |
| 7                  |         | D                 | 2.2             | 2.7                 | 2.4                 |        |        |           |
|                    | C       | 2.1               | 2.7             | 2.0                 |                     |        |        |           |
| 8                  |         | D                 |              perf |                     |          perf | perf   |        |           |
|                    | C       | 0.8               | 1.0             | 1.0                 |                     |        |        |           |
| 9                  |         | D                 | 2.7             | 2.8                 | 2.5                 |        |        |           |
|                    | C       | 2.3               | 2.7             | 2.4                 |                     |        |        |           |
| 10                 |         | D                 | 0.4             | 0.6                 | 0.4                 |        |        |           |
|                    | C       | 0.3               | 0.4             | 0.3                 |                     |        |        |           |
| 11                 |         | D                 | 0.3             | 1.7                 | 0.7                 |        |        |           |
|                    | C       | 1.0               | 2.6             | 0.9                 |                     |        |        |           |
| 12                 |         | D                 | 0.4             | 1.3                 | 0.5                 |        |        |           |
|                    | C       | 0.1               | 0.5             | 0.2                 |                     |        |        |           |
| 13                 |         | D                 | 0.2             | 0.6                 | 0.1                 |        |        |           |
|                    | C       | 0.1               | 0.5             | 0.6                 |                     |        |        |           |
| 14                 |         | D                 | 0.9             | 1.6                 | 1.8                 |        |        |           |
|                    | C       | 0.1               | 1.0             | 0.05                |                     |        |        |           |
| 15                 |         | D                 | 0.1             | 1.0                 | 0.3                 |        |        |           |
|                    | C       | 0.1               | 1.1             | 0.05                |                     |        |        |           |
| 16                 |         | D                 | 0.4             | 1.3                 | 0.5                 |        |        |           |

**Table 2.** Measurements results of the corrosion loss size on sections' walls in the connecting crosscut at the level of 585 m of the X mine.

Strong corrosion of the housing elements with visible delamination and peeling on the surface of the sections. In the bottom section, up to a height of approx. 1.3 m, perforations of section walls occur spontaneously locally.

Surface corrosion of the housing elements locally increased on the section to a height of approx. 1.5 m.
Exemplary assessment results of the technical condition of mining gallery according to the previously described stages for mine X are shown in figure 9a), while figure 9b) shows the assessment results of the technical condition of mining gallery according to an optical method based on visual tests. The analysis covered 12 main excavations in the X mine. Excavations were made in the LP-8, LP-9, LP-10 linings from sections KS / KO21, V25, V29 or V32 using U-bolt stirrups, type ZS or SD. The arch supports were installed at intervals of 0.5 m, 0.75 m or 1.0 m. Reinforced concrete linings or steel mesh were used as a cover. The age of excavations at the time of conducting the research ranged between 10 and 40 years. The research, in accordance with the above-described Stage II, was carried out by technical employees of the Mining Department specially trained for this purpose. However, in the optical studies of the support lining condition, high-lever supervisors from the Department of Rockburst, Mining and Ventilation were involved. Comparing the results of the obtained research, it can be noticed that they differ significantly from each other. Technical workers based on the conducted tests with the participation of the Metrison ultrasonic thickness gauge, model SONO, type M500, inventory number of mine X - 1011 recognized the condition of the housing in 4 mining excavations as good not requiring intervention, in 4 as bad requiring immediate intervention (rebuilding) and 4 were classified as the so-called emergency excavations requiring reinforcement of the housing. This evaluation was supported by substantive mathematical calculations. Employees assessing the condition of the arch support took into account three parameters: corrosion loss of arch support elements in relation to its nominal thickness, frequency of exploitation of the excavation by mining crews, use of arch support elements for transport purposes. The arch support, which corrosion loss did not exceed 10% of the nominal thickness, was considered to be a good condition, and in the excavation normal crew movement and material transport by suspended rail took place. The arch support, in which the corrosion loss did not exceed 35%, was considered an emergency condition and there was a second parameter associated with normal crew movement or the use of this arch support, eg for transporting material with a suspended rail. The arch support in which the corrosion loss exceeded 35% in longwall excavations and 40% in the main excavations such as tunnels and crosscuts and ventilation walkways was considered a bad condition. The excavations arch support, in which there were deep perforations, was also considered as bad. As a curiosity it is worth mentioning that the result of more than 10 years of research conducted by mine employees, depending on environmental conditions, showed the corrosion loss of the arch support from 20 to 80%.

**Figure 9.** Assessment results of the arch support condition in 12 mining excavations of the X mine. a) based on computational tests b) based on visual evaluation.

The employees of the supervisory body assessing the condition of the arch support of the same 12 mine workings in mine X on the basis of visual assessment considered the lining of arch support in 7
excavations to be good, 3 for emergency work and 2 for bad. The evaluation criterion in this case was noticeable deformation and clear deep perforation changes.

These two different approaches to assessing the technical condition of the mining gallery arch support show the crux of the problem of deaths occurring in recent years in Polish underground mining. The lack of the collapse classification risk and the methodology for assessing the condition of the mining gallery arch support together with its classification depending, for example, on the degree of corrosion loss, means that the managers of mining plants, guided primarily by the economic calculation of the mines, may freely interpret the results these assessments. Professional experience shows that the visual assessment type of the arch support condition is more preferable as the responsibility for its correctness is taken by the high-lever supervising person.

7. Conclusions
The conducted research has shown that the problem of fatal accidents in Polish underground mining in recent years is mainly caused by collapses and / or rock burst from the roof and side walls. In those cases from January 2014 to September 2018, 21 people died, serious injuries were suffered by 15 miners, and slight injuries were noted in 942 people. One of the main reasons for these events is the poor condition of lining of arch supports in excavations or its poor performance. To prevent this phenomenon (as in the case of a fire hazard, 53 events in the years 2014-2018 when 2 people were slightly injured):

- introduce in the applicable mining regulations requirements regarding the same diagnostic method of assessing the condition of steel arch support that underground workers could work in underground conditions.
- introduce a classification of the arch support condition defining the conditions under which it should be absolutely strengthened or replaced.
- introduce the obligation for mines to keep measurement documentation of the technical condition of the arch support, eg on the basis of ultrasonic tests.
- introduce the obligation to create a measuring station in mines and underground mines, which would be like a methane generator responsible for the constant control and measurement of the corrosion loss of each steel arch support in all underground mine excavations.
- as a last resort, as in the case of inspection of the shafts, enter in the mining regulations a record to check the arch support in mining excavations once every 5 years, this should be carried out by an appraiser.

The author's own experience in managing the Mining Works Department at the X mine and the conducted research show that the two-stage arch support condition assessment conducted by the mine employees is feasible and brings tangible results. Since 2003, no events related to the collapse and / or rocks burst from the roof and side walls have been recorded in the mining excavations of mine X, and the inspection of the arch support condition improves the safety of mining crews in the mine workings.

Constant monitoring and documented measurements of the frame support thickness allow for the current observation of the changes occurring in it. They also give arguments to the head of the Mining Works Department for negotiations with the Mining Plant Movement Manager regarding the allocation of financial resources for the necessary preventive measures to prevent mining disasters resulting from the poor condition of housing.

8. References
[1] Assessment of work safety, mining rescue and general safety in connection with mining and geological activities in 2017 (comparison to 2013). Higher Mining Office. Katowice 2018
[2] Work safety in conditions of rock bursting and rock falling from the roof and side walls. Training materials of the Higher Mining Office. Katowice September 2018
[3] Work safety in the conditions of a rock bursting. Training materials of the Higher Mining Office. Katowice September 2018
[4] Duży S 2013 Bud. Gór. Tunelowe 19 (1) 31
[5] Rotkegel M et al 2003 *Principles for control of the technical condition of the frame support in the corridors of the "Bytom III" corridor*. Documentation of research and service work No. 411 37813-151 GIG. (Katowice: GIG)

[6] Instruction no. 204/7 / TOT / 2007 on a detailed inspection of the technical condition of the arch support of the mining galleries. Source materials of the X Mine.