Comments on Rock blasting

Flyrock (part 03 of 03)

By Bruno Pimentel.

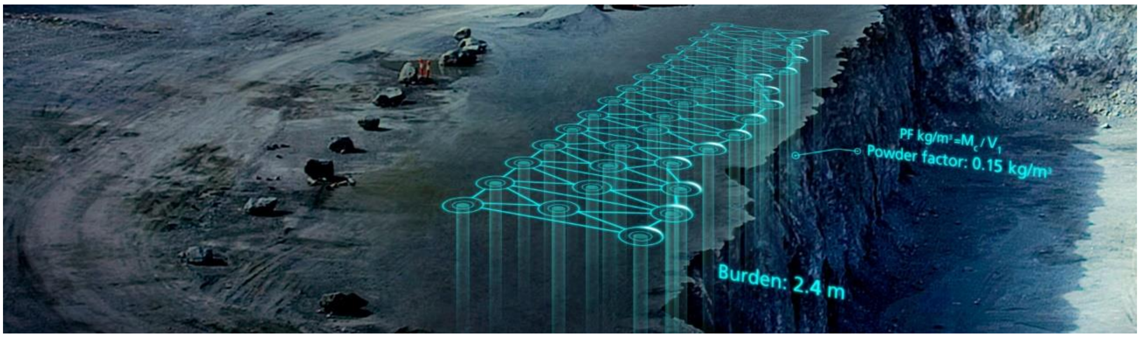
Hello my friends, I hope you are all well, and for those who are arriving now, I invite you to sign up through the link below, and of course, do not forget to check out the previous articles:

Portuguese: https://www.linkedin.com/newsletters/desmonte-de-rocha-c-explosive-6941709482355748864/

English: https://www.linkedin.com/newsletters/rock-blasting-6959820770344595456/

This is our third and final article on the subject of Flyrocks, which has been a topic that has been extended a lot, but it is a very important topic, which should not be left out in blast to open pit operations, as we have already commented before , one of the big problems with flyrock events is that they go beyond our control radius, which physically is our clearance zone, so the consequences can be diverse and disastrous, and that's why in today's article, we'll do just a few comments, many of them very generic, about the prevention of this type of event and aimed at ensuring greater security for our blasts.

First, we need to be clear that the only way to eliminate the risk is to simply not perform the blast, because from the first moment we start to execute our blast, we are already exposed to several risks, and that includes the flyrock. For example, even during loading, we can have the premature triggering of one of the holes, and in addition to the close damage caused by the blast of this hole, it can throw fragments at great distances, which causes events that can be considered flyrock, even if in this the moment we still don't have our clearance zone in operation.



So, assuming that we need to perform the blast, from the beginning of the preparation of any blast, we need to look for measures that will control the risks present, including the risk of flyrocks.

Of course, we have blasts that will naturally present minimal risks, which can be extremely punctual, or in remote areas, with the possibility of carrying out a clearance zone from kilometers away, or we also have controlled blast techniques, which will control at the same time the material's maximum release and the action of the explosive during the blast, but even in this type of blast, we are subject to exposure to risk during its preparation, and also to errors and failures, which can occur in its execution and can cause unwanted events , in addition to the fact that many of the techniques used for control, such as the use of protective blankets, cannot be applied, operationally speaking, to all types of blast, such as large production blasts with hundreds of tons of explosives and hundreds of square meters of area to be blasted.

So we first need to consider that every blast is a risk, no matter how controlled it may be, and mainly, that we may have critical conditions that can get out of our control or not be identified, and so considering that the risk will always be present, the best way To control this risk, it is through the implementation of preventive measures, which will start with the elaboration of a balanced design and adequate to the conditions of each blast, and must end with effective quality control in the execution and realization of each blast.

As we mentioned in previous articles, during a blast there are several factors that can be sources of flyrocks, and some of these factors can be controllable, such as the amount of explosive we use, but others are uncontrollable factors, such as for example a cavity inside a hole or several interconnected fractures, which can cause us to have an accumulation of explosive, increases the risk of flyrocks.

When we look at the controllable factors, the best form of prevention is through quality control, both related to sizing and execution, so that we can guarantee that we will have each parameter correctly determined and executed correctly. So for example, when looking at the amount of explosive to be used, we first need to ensure that in the design of our blast we apply an adequate power factor, not only for the type of material, but balanced with all the other parameters and conditions of our blast, as well as during the execution of our blast plan, we need to ensure that this amount of explosive is applied, and in addition, that when identifying any situation different from the base parameters used in the design, this amount is properly reassessed, so that it adapts to these new ones. parameters, for example as a short hole or even with a small burden.

On the other hand, uncontrollable factors, as the name implies, are factors that we cannot control their quality, and therefore, the best way to prevent these factors is through the knowledge and identification of their conditions in each blast, because from the moment we know these conditions, we can carry out control measures that minimize the present risks. As is the example of the presence of a cavity, which will normally be unknown during the design, but needs to be identified during loading, so that we can assess its conditions and the possible implications, because although we can have the same planned amount of explosive in a hole, the fact that a large amount is concentrated in the cavity can generate unexpected results, but once we identify this condition, we can take preventive measures, both for this hole, as well as for others that may have similar conditions.

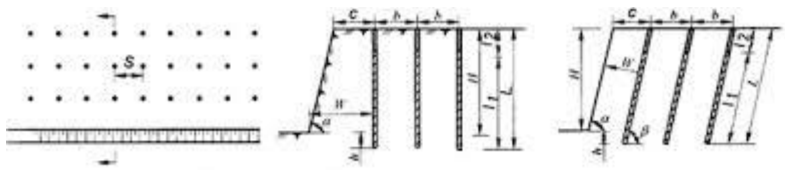
As soon as I keep in mind the control of controllable factors and the identification and treatment of the uncontrollable ones, remembering that some of them we have already commented on in the last article, in this article today, we believe it is necessary to reflect on each of the points below:

- ✓ Design parameters
- ✓ Operational controls
- ✓ Critical thinking and proactivity
- ✓ Reviews before loading
- ✓ During loading
- ✓ Post load conference
- ✓ Clearance zone
- ✓ Communication
- ✓ Technology
- ✓ Training
- ✓ Critical and punctual situations

- **Design parameters**

As we said before, we consider that there are no flyrock control techniques, because the techniques we use control the general launch of the blast, and this implies the control of points that will contribute to minimizing the risk of flyrocks, but will not eliminate this risk, so when designing any blast, we need to consider that the risk always exists and so we need to establish control measures to minimize this risk.

So, the first step to avoid any problem in a blast is to carry out a suitable design, with balanced parameters that suit each situation. For this we need to optimize the balance between the rock properties, the site characteristics, the explosive distribution and the confinement conditions of this explosive, where a logical approach is to adjust the energy/explosive distribution and its confinement, according to the properties of the rock and the characteristics of each blast, which includes possible anomalies and specific conditions.



H - Bench Height   W - Burden of the Holes of First Row   L - Depth of the Blastholes
l_1 - Charge Length l_2 - Stemming Length   h - Subdrilling α - Angle of Bench Face
β - Clined Angle of Blastholes   S - Spacing between Blastholes in a Row
b - Distance Between Rows   c - Safe Distance between the bench edge and first row of Blastholes

Here we want to pay special attention to the operations that use standard blast plans, normally established according to the type of material, because although the general conditions of the materials can be constant, and so we can, for example, use a power factor or drill pattern standard, we need to be aware of the differences of each blast, which may present anomalies in the rock or critical conditions, and therefore, although the standard plane is the starting point for the design, we must adjust this plane to the specific characteristics of each blast, and here in our case, not forgetting that these adjustments should serve to avoid the generation of flyrocks, for example, we can control the load of holes in the first line, or evaluate a better sequencing for holes that are at the ends and may need a greater relief.

Today we have several software and measurement equipment available, which help us in the design, simulation and identification of critical conditions, and whenever possible the use of such technologies has a fundamental role in the realization of a good design, as it allows us to quickly make several evaluations and thus make decisions based on several possible scenarios.

There are several parameters for a blast, and most of the formulas and concepts available indicate the individual calculation of each one of them or related only to one or another parameter, but we must always keep in mind that the result of our blast will depend on the interaction between all the vestments, so our goal should always be to seek a balance that gives us greater control over the blast, where we can predict with good confidence the main results, and thus understand the behavior of our blasts in the main possible situations , as it helps us make better guesses about specific situations we might encounter.

For the realization of new designs, in areas or materials where there is no history, it is important to have an additional precaution, having greater control over the parameters, and whenever possible carrying out more controlled tests or blasts, to understand the normal behavior of the parameters, so that we can optimize them over time, with greater security and with controlled risks.

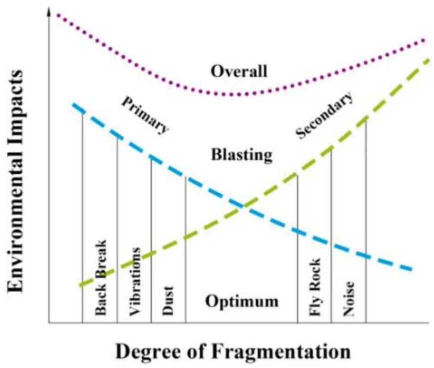
Finally, we need to remember that when performing a blast, normally a large part of the explosive energy is wasted, and this waste has 3 main implications, the first is the reduction of the portion that should contribute to the achievement of our goals, for example, the greater the waste, the worse our fragmentation, second, that by wasting energy from the explosive we are directly increasing the costs of our blast, because if we made better use of energy, we would need a smaller amount of explosives, and finally, the third implication, is that the wasted energy is responsible for generating the undesired effects, so the greater this waste, the greater the risk of this portion of energy generating flyrock events, and therefore, maximizing the targeting and confinement of the explosive energy, should be the starting point of any drawing.

- **Operational controls**

Once we have an adequate blast plan for the blast, where the parameters are balanced, we need to guarantee an operational quality that allows us to execute the blast plan with precision, but for that, the first step is to verify if the blast plan created is really compatible with the actual conditions of the blast, because unfortunately, as we said, many operations have standard plans or the person responsible for carrying out the plan design does not have the real information about the blast and bases the preparation of the plan on theoretical information, so the first step must be revise the plan according to local blast conditions, and where necessary, make appropriate adjustments to ensure control.

For example, it is very common to have irregular burdens in the first line, and most of the time they are not included in the theoretical blast plan, and therefore, the person responsible for loading must evaluate the expected load for these holes and make adjustments when necessary, minimizing the risks of frontal flyrocks.

Once we have the appropriate blast plan, operational quality comes into play, which must guarantee a good execution of the loading and preparation for the blast, which is the most important step of the entire process, including estimating that the execution is responsible for approximately 80% of the blast's result, both in terms of our objectives and in terms of the impacts generated by the blast.



Probably some of the next articles will be about operational quality control, which despite being the primary part of any blast, unfortunately many operations still have many opportunities for improvement.

In addition to guaranteeing the quality of the blast plan execution, it is during the operation that we have the greatest contact with the conditions of the blast, and this is the time to identify present anomalies, whether in the characteristics of the rock, the blast itself or the products we are using.

At this point, it is important to carefully evaluate the blast, seeking to identify points that may generate risk scenarios, such as irregularities in the free face, anomalies in the hole, or even divergences in the characteristics of the rocks.

For this, two fundamental points are a good risk assessment and good operational procedures, which are more than mere records and really serve as a good guide in the execution of a safe activity. For this, we need to seek assessments that fit the reality of each operation, as well as the procedures need to be constantly reviewed, adapting operational practices and safety recommendations.

Many operations use blast checklists, as a way of remembering the points that must be reviewed and to help identify anomalies, but it is important to assess the conditions and capabilities of each team, so that they are actually applying useful and real criteria, to that we can implement adequate preventive measures for the identified occurrences.

The truth is that this is a point where there are many difficulties, or rather "hidden opportunities" in most operations, where there is usually a lack of time, resources and conditions to perform as it should, and besides the fact that most of recorded flyrock accidents, indicate operational failures as the main causes of events.

In order not to extend this point, which would perhaps take more than one article, here we just want to raise the alert regarding the **quality of execution, the identification of anomalies and the implementation of adequate control measures**, as the main points necessary to guarantee safety in our blast.

- **Critical thinking and proactivity**

Two terms that suit our theme well are critical thinking and proactivity, these two characteristics being fundamental for those responsible for leading blasts and identifying anomalies that can generate flyrock events. So I will leave here the definition of these terms that in practice make all the difference:

Critical thinking is the ability to question and analyze rationally and intelligently. Through critical sense, man learns to seek the truth by questioning and reflecting deeply on each subject. The word “criticism” comes from the Greek “kritikos”, which means “the ability to make judgments”.

Proactive is someone who acts in advance, avoiding or solving future situations and problems.

So, in summary, we can say that it is extremely necessary to act in advance (proactivity), so that we can carefully analyze each blast (critical sense) seeking to identify unusual situations that may represent a specific risk in the generation of flyrocks.

- **Reviews before loading**

One of the fundamental steps to guarantee the quality control of any blast, is to carry out an evaluation before starting the preparation and execution of our blast, which is what we normally call evaluations before loading.

Today most operations will have their standard risk analysis, where some are divided into stages and last throughout the activity, and others use several assessments, to be used at each stage of the activity, but in addition to these assessments, which are fundamental to ensure the safety of the activity, a competent professional must make a critical assessment of the scenario of each blast, always keeping in mind that the early identification of risk conditions allows greater possibilities of control.

We need to understand that if we identify the problem, only after the blast is ready, our options for control measures are much smaller, while if we identify in advance, we can even stop the operation, until we have established an effective control for each situation.

In an efficient operation, before starting the loading of our blast, we will carry out **a risk analysis** to ensure the safety of the activity, we will **evaluate the conditions of the blast**, seeking to identify any anomalies present, we will **check the basic parameters** already carried out (plan drilling), we will **evaluate the conditions identified** in front of the blast plan to be executed, and before starting the activity, **we will establish the control measures to be used**.

We are aware of the difficulty of many operations, where programming and time often do not allow for an adequate preparation of the beginning of the activity, and many of these points are performed during execution, because for example, we have operations that while preparing the blast, the material from the previous blast is still being extracted, so we don't have the free face available to make the necessary evaluations, but in each situation we must develop ways of working that adapt the control needs to the operational conditions, where in this example, we could prepare all the blast, leaving the holes close to the free face to be loaded last, so with regard to this part of the blast we could make a further evaluation, but that would be before loading these holes.

As simple as the preparation activities seem, such as checking the free face, measuring the holes, analyzing the bench conditions, evaluating the material to be used in stemming, and these basic points, it is with this information and at that moment, that we have the most control over our blast, where we can still make any changes, based on actual conditions, and thus, the established control measures will be much more effective.

- **During loading**

Regardless of whether or not we carry out a good assessment and establishment of control measures before starting loading, during loading we also need to be aware of the possibility of initial conditions changing and confirmation of the expected loading characteristics for each hole.

So, during loading, we need to confirm that the conditions identified above remain the same, as, for example, a good hole can be blocked due to the fall of some material during loading, which is why we need to be aware, because any change in the predicted conditions , may imply the need for changes in the established control measures.

Just as it is during loading, we need to ensure that the application of the explosive will follow the established parameters, so constant monitoring of the loading is essential for the safety of the blast. For example, it is during loading that we identify if the explosive charge is staying in the design configuration, if the stemming is at the programmed height, or if there are anomalies that are interfering with the load configuration.

This is where the entire operational quality control issue that we talked about before comes in, where we have to guarantee the quality of the products we are using, that they are being applied correctly, and that the application parameters are following what was determined by the blast plan.

- **Post load conference**

Once the loading and preparation of our blast is finished, it is always recommended to do a general check before starting the blast procedure, evaluating the blast plan performed, the clearance zone and the positioning of structures and equipment, to make sure that nothing has passed. unnoticed. The best way to prevent flyrock is always keeping in mind that it is a constant hazard and must always be controlled.

As we said before, most of the causes of flyrock events are related to human error, so at this moment we need to do a complete check of the loading and sequencing of our blast, evaluating if we have anomalies in the loading of the holes or if the sequencing is following the correct order.

Unfortunately at this point we no longer have the control to change the load of a hole, but we can still change the sequencing or even increase the clearance zone, so it is important to ensure that controls are in place, and assess whether we still need additional measures.

At this time, some operations will also have established verification procedures or blast checklists, to try to facilitate this final conference stage before the blast, but regardless of the practices carried out, the important thing is to ensure that we have the necessary conditions to perform a safe blast, because although the risk is already present, until we start the blast, it is still under our control.

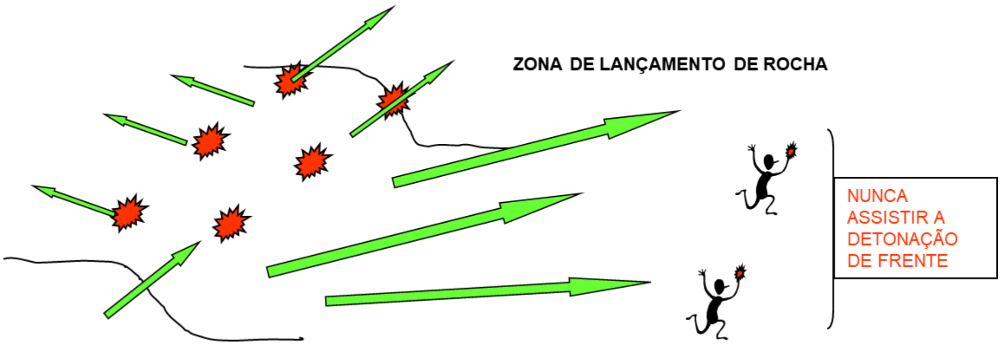
- **Clearance zone**

Our last control measure is the clearance zone, which we have talked about before and we even have a previous article talking extensively about the subject, so we will not extend it here, but it is important to remember that our clearance zone is the limitation of the area that must be be under our control, so it must be established according to the characteristics and control we have over our blast, in the same way that the flyrock definition is linked to the clearance zone, so we must always reevaluate the conditions of each blast and when necessary increase our area of control.

The correct definition of the clearance zone is of paramount importance, because in addition to defining the safety zones, it is the determining factor for the classification or not of flyrock.

The set of all primary and secondary blasts that will be carried out for the composition of the clearance zone must be evaluated, always following the most critical limits.

The forward projection of the blast is usually much more pronounced, so when defining the clearance zone, consideration should be given to increasing the frontal distance.



- **Communication**

Linked to human error, communication errors are a constant failure in many operations, it is unfortunate to hear expressions such as: I thought you had seen it, I commented to the other and I thought he was going to tell everyone, and so on.

Good communication between the team and ensuring that all those responsible and involved in the activity know the correct information as soon as possible is essential to ensure the establishment of effective control measures.

For example, knowing that we have problems in a hole before loading or before stemming allows us to make adjustments to the loading, but if we only know after the hole is loaded and stemmed, our options are quite limited.

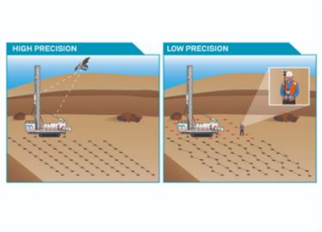
That's why it's essential that everyone is alert, properly trained to identify anomalies and risk situations (many of which we commented on in the last article), and that the flow of information flows constantly, so that actions are taken at the right time.

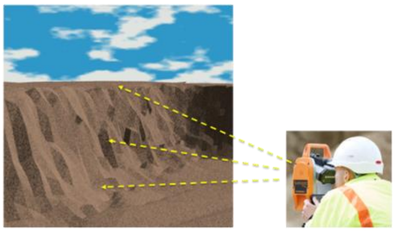
Ensuring constant and present supervision during all stages, and that the person in charge has effective control and communication about the operation, is one of the most critical items to guarantee a safe and quality blast.

And here I just want to leave an alert, because these things seem simple, but the cases we've seen range from the definition of silly mistakes to the most absurd things in life, where we've seen people who are present and have no idea what is happening and others that haven't even set foot in the area.... **the details matter**...

- **Technology**

Today we have several technologies that can be applied to have greater control over our blasts, which is why we must make the most of it, according to the characteristics of each blast.






Technologies and equipment help us to have more precise measurements, which allow a better dimensioning of the blast plan and control over the execution of the established parameters. For example, free face measurement technologies such as laser profile or even inline scanners allow for more controlled burden definitions and load settings suited to each hole.

Electronic blasters allow us greater control and flexibility in the sequencing of our blast, pumped explosives, a better load configuration, monitoring technologies, such as high-speed cameras, allow us to better understand the behavior during the blast, and thus establish parameters and more effective control measures.

Not to mention the design and simulation software, which allow us to perform a series of scenarios quickly and compare different faces, giving us greater control and precision over the planning of our blasts.

Later on, we will dedicate some articles to talking about the available technologies and how to take better advantage of them.

- **Training**

Constant training of the entire team is essential, not only for them to carry out the activity correctly, but for everyone to be able to identify abnormal situations and understand the clear need to establish control measures.

Everyone involved in blast preparation needs to be aware of the importance of all parameters, such as stemming or hole loading configuration, so that when identifying anomalies they can act quickly so that control measures are established.

It is important to keep in mind that constant training is the best way to avoid human error, ensuring that everyone is constantly evaluating during activities, that the team has the ability to identify critical points, and that they can establish effective controls.

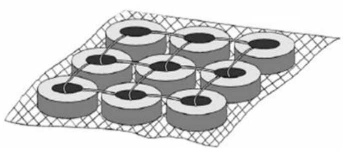
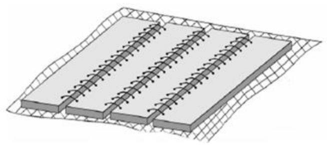
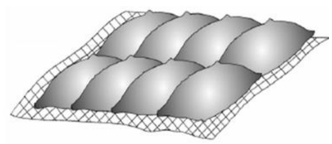
Those responsible for the loading operation must have the technical capacity to make concise assessments of blast conditions and parameters.

We cannot forget that automation and technology bring many control tools, but if the people behind their operation do not understand the process, we will continue to make the same mistakes.

- **Critical and punctual situations**

Finally, one last point that we cannot forget to mention is about the existence of critical or punctual situations, which can arise in any type of blast, where, for example, we can have a high-risk scenario, such as a blast in a urban area, or we may have just one borehole with very little burden, and each such scenario will need an equally unique solution to ensure we have control of our blast.

As we have already said, there are several techniques of controlled blasts that can be used, such as the use of blankets that help to contain the launch of fragments, which are widely used in blasts in urban areas and in risk scenarios, and that despite not operationally viable in large blasts, they can also be used in a punctual way to contain a hole with inadequate burden or stemming.

We need to understand that each situation and scenario needs to be carefully evaluated, so that we can identify the real situation and thus assess what will be the best control measure for each of them, and that we may often have to sacrifice some objectives to ensure effectiveness of control measures. For example, in a blast where we have a very light hole, we can choose not to load that hole or just a small decoupled charge, to control the risk of flyrocks, and this may imply that the back hole becomes heavier and thus has its launch or fragmentation impaired.

In the same way that several of the measures used for the control of flyrocks also apply to the control of other unwanted effects of our blast, so we need to ensure that one of our central objectives when performing a blast, is the reduction of impacts and unwanted effects, and that this objective may not always be in agreement with the others, such as greater fragmentation, but that our central mission is to find a balance between them, in a way that we have acceptable results and increasingly safe blasts.

So, in summary, to finish our flyrocks theme, here are the points that we cannot forget to guarantee a safe blast in all aspects:

• Design of a balanced blast plan suitable for reality

• Quality control in blast preparation and execution

• Identification of anomalies and critical situations

• Establishment of adequate control measures

• Specific treatment for specific situations

• Use of technologies for measurement, monitoring and control

• Well-trained, proactive team with adequate critical thinking

• Up-to-date work procedures in line with standard operating practices

That's it, here we are finishing our third article on the subject of flyrocks, so I look forward to seeing you in our next article, and we are open to suggestions for themes that we believe can help improve the standard and security of our blasts.

Please comment and share, so that we have more and more safe and quality blasts!!

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