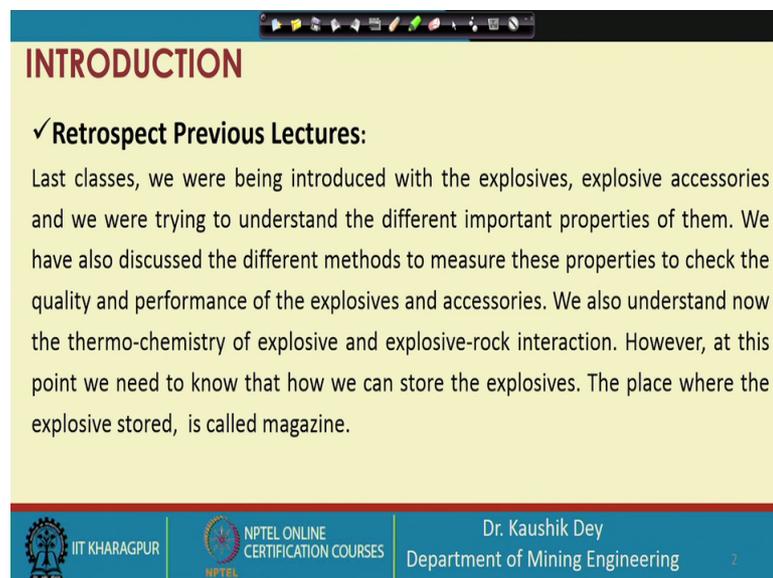


Drilling and Blasting Technology
Prof. Kaushik Dey
Department of Mining Engineering
Indian Institute of Technology, Kharagpur

Lecture - 26
Explosive storage and transportaion-1

Let me welcome you in the lecture number 26th in the Drilling and Blasting Technology course. In this class, we will discuss about the Storage of Explosive.

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INTRODUCTION

✓ **Retrospect Previous Lectures:**

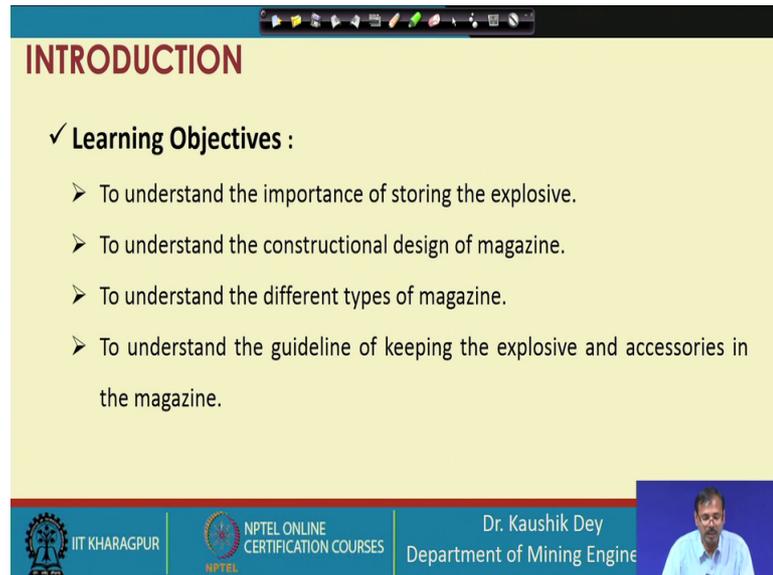
Last classes, we were being introduced with the explosives, explosive accessories and we were trying to understand the different important properties of them. We have also discussed the different methods to measure these properties to check the quality and performance of the explosives and accessories. We also understand now the thermo-chemistry of explosive and explosive-rock interaction. However, at this point we need to know that how we can store the explosives. The place where the explosive stored, is called magazine.

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And for a like every class, let us retrospect what we have carried out in our previous lecture. In last few classes we are being introduced with the Explosive, Explosive accessories. We have also understand their important properties that how those explosives and their accessories are behaving based on those properties and we have yes discussed also the different methods to measure those properties and to check the quality and performance of this explosives.

And after that we are introduced with the thermo-chemistry of explosive and the explosive-rock interaction. That means, how the on detonation how explosive behaves how it generates energy in terms of shock and heat and how the energy is transferred from the explosive to the rock; then, how the structure or fragmentation in the rock occurs? So, that part is already discussed in the previous lectures. At this point let us go little bit the other side that how we are going to store the explosive and its accessories.

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INTRODUCTION

✓ **Learning Objectives :**

- To understand the importance of storing the explosive.
- To understand the constructional design of magazine.
- To understand the different types of magazine.
- To understand the guideline of keeping the explosive and accessories in the magazine.

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So, our learning objective for this class is: To understand the importance of storing the explosive. To understand the constructional design of a magazine. magazine means the place where the explosive must be stored; To understand the different types of magazine and to understand the guideline of keeping the explosive and accessories in the magazine. Basically this is our learning objective for the next 2 classes this class and the next class.

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But like every class, we do let us observe the video of this magazine. In this video you can see the explosives are stored in the magazine and there are few gaps between a lot of explosive and in that gap you will also find out some spaces are given for basically the ventilation purpose.

Here, you must remember that the most of the explosives generates gases and the accumulation of those gases are must be avoided because those are flammable gases. So, that is why it is essentially require that the ventilation must be provided inside the magazine. So, that the gases produced must be taken out and there should not be accumulation of the heat inside the magazine. So, you can see this is a very huge magazine in which huge quantity of explosives are stored. And that is why sufficient safety measure has to be taken care for this magazine.

So, we will discuss what are those safety measures require how what are how this explosive can be stored in the magazine; what will be the way of keeping the explosive inside the magazine and the explosive accessories should be put them together or should be keep them differently? So, all this has to be discussed in this class.

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HISTORICAL ASPECTS OF MAGAZINE

Colonial Williamsburg, Verginia, 1715 this magazine was built to store the Gun powder. This first magazine of the history was built to fight with the American natives.

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But let us see the historical aspect of the magazine. You can see this is the first magazine build up in Colonial Williamsburg, Verginia, in 1715. So, this is the world, this is the world's first magazine build up in Virginia and this was basically build to store the arms and explosive to fight with a natives of the Americans and the Europeans. So, Europeans

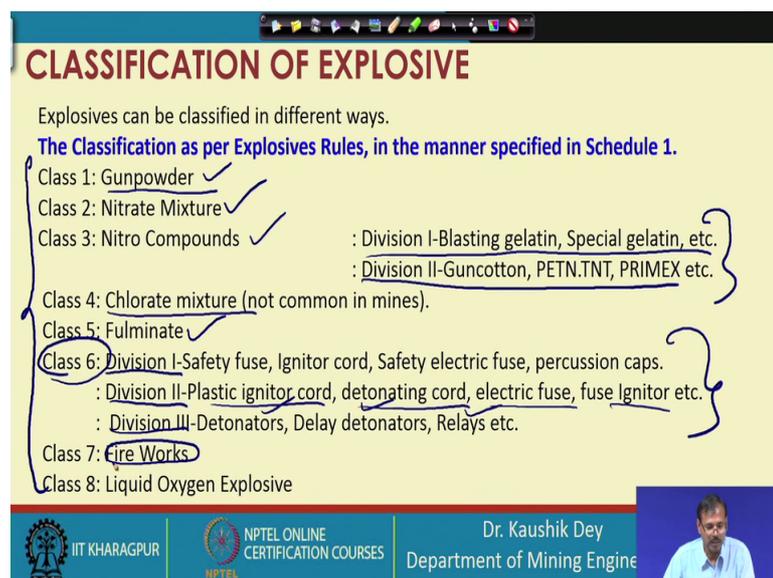
kept the arms and ammunition in this building and it was guarded heavily so that they can fight with the natives of the American. Now this magazine is now this magazine is kept as a tourist spot.

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And you can see this is very this is the security guard, magazine at 10 feet high wall this and this presently tourist spot is nowadays very very popular tourist spot in the Williamsburg.

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Now, let us look in to the classification of explosive a little bit. As per our explosive rule and the CMR MMR, the explosive classifications are like this. We classify our explosive in 8 class and this 8th class, the first one is the Gunpowder which is basically a low explosive; then, the Nitrate Mixture; then, the Nitro Compounds. This Nitro Compounds is further divided in 2 divisions. This is Division I- for the Blasting gelatin, Special gelatin mines; these type of gelatinous explosive in which in which that nitro glycerin is mixed with the ammonium nitrate or other things and Division II- is basically Guncotton, PETN.TNT, PRIMEX etcetera.

So, this is coming under class 3, nitro compounds with explosives; class 4 is chlorotech Chlorate mixture which is explosive, but in Indian mining contest, it is not very common. Class 5 is fulminate; this is also not common in Indian mining sector; class 6 is basically kept for the accessories, class six is the accessories in which it is again classified in 3 divisions. Division I is for Safety fuse, ignitor cord, Safety electric fuse like this. Division II is the Plastic ignitor cord, detonating cord, electric fuse, fuse ignitor etcetera and Division III is basically Detonator, Delay detonators, Relays. Relays is also another type of Delay detonators which is used in the surface plastic.

So, basically this class 6 is dealing with the accessories. Class 7 is Fire Works means which is allowed to use in the common public places and class 8 is Liquid Oxygen Explosive. Though now a day's, we do not use liquid oxygen explosive in our mind; so that is why it was not discussed in detail where we discussed about the explosive, but earlier in factory middle of the 90's liquid oxygen was a very very common explosive used in the surface mine.

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CLASSIFICATION OF EXPLOSIVE

On this basis of risks which explosives present on initiation

- Category X - Explosives having a fire or a slight explosion risk, or both, but the effect is local.
- Category Y - Explosives having a mass fire risk or a moderate explosive risk but not the Risk of mass explosion.
- Category Z - Explosives having a mass explosion risk and major missile effect.
- Category ZZ - Explosives having a mass explosion risk and minor missile effect.

Schedule VIII of the Explosives Rules gives the safety distances to be observed for/from magazines, licensed of the storage of high explosives, of different capacities, of the different categories (X, Y, Z, ZZ) of the explosives.

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Apart from that the explosive may be classified in some other basis also say on the basis of risk, on the basis of risk explosive is classified in 4 groups: Category X, Category Y, Category Z and Category ZZ and if you see the severity of this explosive Category X basically classified where the explosives having a fire or a slight explosion risk or both; but the effect is local. That means, if you ignite the explosive knowingly unknowingly, the risk is that it can fire something else, it can explode also; but the effect is local that the distance up to which it will affect it is not significant.

Category Y is that there is a mass fire risks that means, huge fire or flame will be generated; Moderate explosion risk that means, the explosion distance will be limited not very far; but the risk is moderate. Category Z is where the mass explosion risk is there and the major missile effects are also there; that means, the gas generation is high and the mass of the material metal or the rock, we may goes up to a longer distance as a missile. So, that risk is also there.

So, explosion risk is there and that means, soft generation is very high apart from that the flowing of object is also very high that is that is coming under category Z. Where, Category ZZ gives us the mass explosion risk means the soft generation is very high, but the minor missile effect that means, the amount of gas generated or the flying of the object risk is little bit is that is called Category ZZ ok.

So, based on this schedule 8 of the explosive rules the safety distance to be observed and from their for or from magazine and the storage of high explosive of different capacities are allowed for that magazine depending on the type of explosive.

So, this risk type is very very important while the storing of them in the magazine is a point of observation.

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CLASSIFICATION OF EXPLOSIVE

On the basis of strength

Low Explosives: Ex: Gunpowder
Where the VOD is less than the velocity of sound (sub-sonic)

High Explosives: Dynamites, Slurries, Emulsions etc.
Where the VOD is less than the velocity of sound (sub-sonic)

On the basis of sensitivity of an explosive to initiation by a detonator.

Cap Sensitive: Are the explosives which can be detonated by a No.8 detonator (Ex: All Permitted, all NPSD, LD boosters/primers)

Non-Cap Sensitive: Are those explosives which cannot be detonated and need a cap Sensitive explosive for detonation (ex: ANFO, LD column charges)

The slide includes logos for IIT KHARAGPUR, NPTEL ONLINE CERTIFICATION COURSES, and NPTEL. It also features a small video inset of Dr. Kaushik Dey, Department of Mining Engineering.

On the basis of strength this is already discussed that we classify it into low explosive, where the VOD is less than the velocity of sound. That means, the subsonic VOD in that case the explosive is considered as the low explosive, if it is supersonic then sorry this line is wrong ok; when the VOD is more than the velocity of sound velocity VOD is more than the velocity of sound, then it is called high explosive.

On the basis of sensitivity we have already discussed this property. On the basis of sensitivity explosive is categorized in the cap sensitive non cap sensitive and cap sensitive is considered, where the explosive can be detonated using the strength of a number 8 detonator. So, number 8 detonator that the detonating present generated from the number 8 detonator if that is able to initiate the explosive that is called cap sensitive explosive.

If it is not in that case it is called non cap sensitive explosive. In fact, Emulsions, Slurries these are non cap sensitive explosive and boosters primers these are the cap sensitive

explosive. So, sensitivity of explosive is very very important while we are designing our blast or storing our explosive.

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CLASSIFICATION OF EXPLOSIVE

Use basis

Permitted explosives: For use in underground gassy coal/non-coal mines, or excavations with explosive environment. (LD)

Non-permitted Explosives:

Small dia.(NPSD) : For use holes of small dia (32mmdia (Pradhan), <165 mm (Langefors))

Larger dia.(LD) : For use holes of large dia (>100mmdia (Pradhan), >165 mm (Langefors))

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And basis on the basis of use explosive is classified in 2 groups; one is permitted explosives, another is non-permitted explosives and we have discussed in the explosive property that the permitted explosives are the explosives which can be used in the explosive environment, which can be used in the explosive environment and that is why in underground gassy coal mines or gassy non coal mines also permitted explosives are desire to be used in all other cases we are allowed to use non permitted explosive.

Further, the non permitted explosives are classified in 2 groups; small diameter, large diameter. As per Pradhan, the small diameter is considered as the 32 mm or something like that; as per Langefor's Kihlstrom small diameter is considered as to be less than 165 mm dia and large dia as per Pradhan is more than 100 mm dia is considered; as the large dia as per Langefor's Kihlstrom, it is greater than 165 mm dia is considered as the large dia. You must note that in permitted explosive there is no question of large dia.

The reason is that as it is carried out in the explosive environment. Obviously, that charge quantity has to be controlled and to control the charge quantity, the question of large dia use of large dia this type of cases are not arising. So, that is why large dia explosive for the permitted is not available only the small dia permitted explosives are available only.

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CLASSIFICATION OF EXPLOSIVE

U.S Department of Transportation classifies explosives as:

- Class A: Explosives possessing detonating or otherwise maximum hazard.
- Class B: Which possesses flammable hazard.
- Class C: Which contains Class A or Class B explosives or both.

Explosives on the basis of Fume Classification(USA)Permissible(MSHA-US).

-Toxic gases must not exceed 71 litres/454gm. of explosives.

Non-permissible (IME-US)

- Class-1- Less than 0.16 ft³ of toxic gas per 1 ¼ in x 8 in cartridges of explosive(200gm)
- Class-2- 0.16 to 0.33 ft³ of toxic gas
- Class-3- 0.33 to 0.67 ft³ of toxic gas

The USBM limits poisonous or toxic gases to 2.5 ft³/pound of permissible explosive.

Handwritten annotations: } x, y, z, zz next to Class A, B, C; } α next to Fume Classification; a box around Class-1; circles around Class-2 and Class-3.

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This is the classification of explosive as per US standards. In US the explosives are classified as Class A, Class B, Class C; where, Class A is the Explosives possessing detonating or otherwise maximum hazard; Class B possessing flammable hazard and Class C possessing both Class A and Class B. So, it is similar to our x, y, z and zz classification which we are classified.

So, our that that classification is similar to this US classification. Another classification is there in US basis of the Fume Characteristics considering the health risk of the users or the pollution coming into the atmosphere; though this type of classification is not available for the Indian mining context. But you can see this classification is that first criteria is that the Toxic gases there should not be more than 71 liter generation of 71 liter of toxic gases per 454 grams of explosive ok.

So, here the classifications are like this. Class-1- where less than 0.16 cubic feet of cubic feet of toxic feet cube of toxic gases are generated from a cartridge of this one or you can say 200 grams of explosive. If the generation is between this two; this is considered from this explosive, this is considered as the Class-2- if the generation of toxic gases is this one from the same this one this is called Class-3.

So, USBM limits the poisonous gas mainly containing CO cetera and toxic gases like NOX Sulphur oxides etcetera to 2.5 feet cube per pound of; this is for pound; this is for

pound of permissible explosives ok. So, this is the US classification, unfortunately in India we don't have this classification this type of standardization of the classification.

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STORAGE OF EXPLOSIVE

Explosives can be stored in a "Magazine" only, and in accordance with the provisions of the rules made under the Explosive Act, 1884.

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So, let us discuss about the Storage of Explosive. Storage of Explosive as per the Indian Explosive Act, 1884 and the explosive rule, explosive can be stored in the magazine only and it must be stored as per the provision given in the explosive rule.

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PROCEDURE TO ESTABLISH A MAGAZINE

Every application for the grant of license, in Form - 22 to possess Explosive for use.
Licensing Authority -

- ✓ For capacities of more than 200 kg - Chief controller of explosive (CCOE)
- ✓ For any quantity of liquid oxygen explosive and Bulk explosive - CCOE
- ✓ For capacities of less than 200kg - Controller of Explosives

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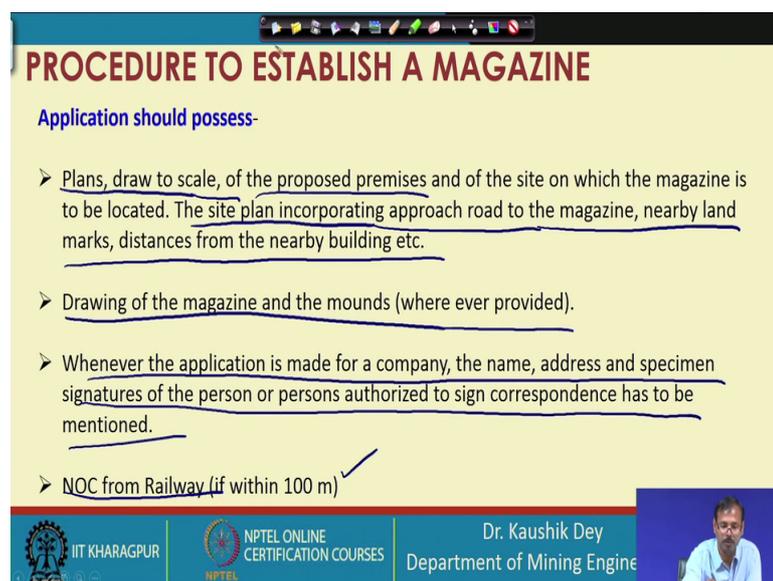
Before discussing into the constructional integrity of the magazine, types of magazine etcetera let us first understand how we can establish get the permission to establish a

magazine. Who will give us the permission whether we are able to use the explosive? We are able to store the explosive as in authorized manner? What is the procedure for that?

Now for getting for establishing a magazine, first we need to have a license for the magazine. And the application must be given for the grant of license in Form - 22. Basically, Form - 22 is describing that you can pose the explosive in your for your own use. The licensing authority will grant this application will grant this application for a magazine of more than 200 kg is by chief controller of explosives; for any magazine with liquid oxygen and bulk explosive. Basically it is not magazine; basically liquid oxygen and bulk explosives are manufactured at the site. So, it is basically the manufacturing of explosive that permission must be given by the chief controller of explosive.

And for the magazine which is less than 200 kg, controller regional controller of explosives are the authorized person to give the license. Now in this case, we have to discuss few more things first is that explosive comes in India, explosive comes under the ministry of petroleum. So, basically for applying this a person has to apply to the ministry of petroleum and the office of the chief controller of explosives is it is at Nagpur and regional application may be submitted to the regional office also, but that can be that will be transferred to the chief controller office, office of the chief controller of explosives.

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PROCEDURE TO ESTABLISH A MAGAZINE

Application should possess-

- Plans, draw to scale, of the proposed premises and of the site on which the magazine is to be located. The site plan incorporating approach road to the magazine, nearby land marks, distances from the nearby building etc.
- Drawing of the magazine and the mounds (where ever provided).
- Whenever the application is made for a company, the name, address and specimen signatures of the person or persons authorized to sign correspondence has to be mentioned.
- NOC from Railway (if within 100 m) ✓

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Now, the application should have all this applications for granting the license of explosive should have a plan of the proposed premises. That means, on the land on which the magazine has to be built up that must be plan and a sections of that area must be given or must be a enclosed with the application. The site plan incorporating approach road to the magazine nearby landmarks distances from the nearby buildings, roads, etcetera must be there in the plan.

Then, the second one requirement is the magazine drawing of the magazine; third is the whenever the application is made for a company the name, address, specimen, signature of the person of the authorized person of the company must be there. If it is within the 100 meter of the railway line the NOC from the railways also required.

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PROCEDURE TO ESTABLISH A MAGAZINE

NOC from District Authority-

- The district authority will publish a notice regarding the proposed site of magazine. The objections are heard by the district authority in the presence of the applicant.

Different complains will be evaluated prior to issue the NOC

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The NOC must be taken from the district authority also and district authority must go for a public hearing and the complains observed in the public hearing must be communicated to the person who is willing to setup the magazine and his observation must be included there. So, the district authority has to give the NOC otherwise no magazine can be license for magazine cannot be given. So, NOC from the district authority must be taken and for that the public notice, public hearing is also required and that must be carried out in the local manner.

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PROCEDURE TO ESTABLISH A MAGAZINE

License for ANFO/LOX/Bulk Explosives-

✓ ANFO, LOX and other Bulk Explosives like Emulsion, Slurry are prepared at the place of use. The it is basically represent the explosive manufacturing.

1. To manufacture ANFO explosives for own immediate use,
2. To possess, for own use, liquid oxygen explosives.
3. To manufacture bulk explosives at site (or plant).

For using the above at Mine site, before applying to CCOE for necessary permission, the applicant/user mines have to obtain necessary permissions from the DGMS.

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We have discussed about that lox and bulk explosives. So, license for having the licence for ANFO Liquid Oxygen Bulk Explosive is that basically it is coming under; this is coming under the manufacturing of explosive. So, basically ammonium nitrate fuel oil that is also filled ammonium nitrates are brought in into the blasting site. Then the fuel oil is mixed with that. Similar to the bulk explosive trucks are coming, where the separate ammonium nitrate emulsing emulsive agents, slurry agents all those agents are there. Those are locally mixed there as per the proportion requirement and that is used in that blast site. Similar to the liquid oxygen also; liquid oxygen is also observed in the lox site to prepare the liquid oxygen explosive.

So, basically all these three are explosive manufacturing at the place where the explosive is being used. So, this comes under the explosive manufacturing in the site of own use. So, that is why this comes under the this comes under the explosive manufacturing and for this if it is a mine site the necessary permission must be taken both from chief controller of explosives and the director general of mines safety.

So, explosive manufacturing in this case for the mining case that permission must be taken from the director general of mines safety and from the chief controller of explosives; otherwise it is the chief controller of explosives and the district authority for using this in the local area ok.

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PROCEDURE TO ESTABLISH A MAGAZINE

For Storage Explosives less than 100 kg-

When the explosives is to be possessed for own use under a license in Form-22, the applicant may apply directly to the district authority, together with an application in Form-5, statement in Form-17, and necessary plans for the grant of NOC, forward the application and the NOC to the licensing authority.

Renewal of License-

- License expire in 31st March every year ✓
- Should be applied to renew within 30 days ✓
- Acknowledgement of the renewal application is considered as renewed till the renewal order accepted or rejected.

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So, this is the essential permissions required for the bulk explosives. Now let us see the procedure to establish a magazine for storing explosive less than 100 kg when the explosive is to be possessed for own use own used under a license in Form – 22, the applicant may apply directly to the district authority; together written application of Form - 5 and necessary plans for the grant for NOC and forwarding of the application by the district authority along with the NOC.

So, in that case the first NOC will be obtained then the a permission will be given by the regional controller of the explosives. The renewal of license is also another important matter. You remember the license always expires in the 31st March in every year so that means, if some license is given to you on the first march that licensee will also expire in 31st March. If it is given on twentieth November, then also the license will expire on the 31st March of the next year.

So, all the explosive license are expiring on the 31st March and every year the license need needs to be renewed and this application for the renewal of the explosion renewal of the license for magazine or explosive use must be carried out within 30 days of the expiring of the license. Often what is happened as the application has been made the license will be renewed by the office of the chief controller or explosive or the region controller of the explosive, but that takes time.

So, what will happen? Acknowledgement of the renewal of application is considered as renewed till the renewal order is accepted or rejected; so that means, if the license is expired on 31st March the person is applied for the renewal within a month and that is why the acknowledgement of the renewal application is given to the person. So, that is already given and that acknowledgement is considered as the renewed license till the controller of explosives is deciding whether the license will be renewed or the application of the license will be rejected. So, till that order is coming the renewal application acknowledgement of the renewal application is sufficient as the application.

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The slide is titled "MORE READING FROM" in red. It lists reference books under a checkmark: "Explosive rules", "Explosive Acts", "Pradhan G. K. 1996, Explosives and Blasting Techniques, Minetech Publication", and "SME Handbook". Handwritten blue ink notes include "IBM", "Explosive Controller", and "DGMS" circled together, with arrows pointing to "Explosive rules" and "Explosive Acts".

✓ Reference books:

- Explosive rules
- Explosive Acts
- Pradhan G. K. 1996, *Explosives and Blasting Techniques*, Minetech Publication
- SME Handbook

IBM
Explosive Controller
DGMS

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So, you may have more reading on this storage of explosive use of explosive in the two important for this is Explosive Rules and Explosive Acts; these are available online. These are available online in the IBM website, ministry of petroleum website that is the Explosive Controller website DGMS website.

So, these rules are available in these websites and it is desired that you should have a look on this explosive rules explosive acts as well as the CMR MMR of the mine regulations of the DGMS. Apart from that, you must go through the book written by Dr. G. K. Pradhan about the Explosives Blasting Techniques for the explosives and accessories properties and the construction of the magazines and also SME handbook will give you a good knowledge about the explosive storage.

So, we will continue this lecture into for the next class also.

Thank you.