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SOURCE ACTIVITY TITLE:	**EXTRACTION AND FIRST TREATMENT OF SOLID FOSSIL FUELS** ***Open Cast Mining*** ***Underground Mining*** ***Storage of Solid Fuel***
NOSE CODE :	**106.01.01** **106.01.02** **106.01.03**
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1 ACTIVITIES INCLUDED

This section covers only coal, not peat or other solid fuels. Subsequent treatment of coal, such as fuel conversion, coking, gasification or liquefaction are not treated in this chapter, but are included in related chapters of the guidebook.

2 CONTRIBUTION TO TOTAL EMISSIONS

The extraction and first treatment of solid fuels results in emissions of methane from mining operations. This sector was estimated to be responsible for 22% of national emissions of methane in the UK in 1991 (Gilham 1994). Limited reliable data is available for the other pollutants.

These activities are not believed to be a significant source of $PM_{2.5}$ (as of December 2006).

3 GENERAL

3.1 Description

Coalfields contain a proportion of highly volatile material which is released during the working, extraction and storage of coal. The volatile material is known as firedamp, made up primarily of methane, although other compounds are also present in minor amounts.

The release of firedamp often results in an emission to air as it not always economical to contain the gas, for flaring or use as a fuel.

During coal extraction, the following processes connected with methane emission can be identified:

a) developing access to the coal deposit and its preparation for extraction;
b) coal extraction and transport on the surface;
c) coal processing, disposal, transport and crushing before final use;
d) deposit de-methaning before, during and after its excavation;

e) disposal of spoils from the coal extraction system.

Air containing methane is emitted usually to the atmosphere because its use as fuel or for combustion purposes is not economically viable, mainly due to the high dilution.

3.2 Definitions

Fire-damp - inflammable gas released during the working of coal mines. In general, methane is considered a safety hazard.

3.3 Techniques

Two types of mining operations are considered in this chapter - deep mines and open cast mines. In addition, it is important to note that coal varies considerably from one field to another, depending on its age and geological location. The proportion of fire-damp associated with the different types of mining and the different types of coal have shown considerable variation. Attempts to model the relationship between the proportion of fire-damp and factors such as depth of coal seam, nature of coal and local geology have shown some correlations although the associated uncertainty is very large.

Once coal is extracted, it may be stored, transported internally or exported, or a combination of all three. Associated gaseous emissions continue to occur and it is thought that these will be related to the coal type, the size of the coal pieces, the mechanical disturbance during handling etc.

3.4 Emissions/Controls

In technological processes performed in underground workings, methane is released which, unless taken in by the de-methaning systems, is discharged to the atmosphere by the ventilation systems of the mines. The ventilation systems are the primary and main methane emission source from coal mines. Emission from the ventilation systems is described as ventilation emission. Methane, in this case called “residual gas”, is also contained in the coal extracted to the surface and released during the extraction processes. Emission related to these processes is called emission from extraction processes. This emission constitutes the second methane emission source in coal mining.

Some methane is also contained in the bed rock extracted to the surface with coal and gets released during bed rock disposal. This is the third source of methane emission. The fourth source is the de-methaning systems. The methane collected by these systems is not totally utilised or combusted in flames and some or all of the volume is emitted as “whistler” to the atmosphere.

In open casting coal extraction, there are two main sources of ventilation emission:

- emission from the extracted coal;
- emission from the deposits coating the working.

The primary emission of fire-damp is believed to occur during the extraction of deep mine coal. Open cast mining, since it involves the extraction of coal seams close to the surface, and the handling and storage of coal, are not considered to be as important.

In many cases, firedamp is actively removed from the coalfield, by various methods, normally described collectively as methane drainage. This is primarily for reasons of safety. As an example, in the UK, in 1988, 16% of the fire-damp released by deep mining was vented from methane drainage systems, 11% was captured and used as fuel, 61% was emitted with ventilation air and about 12% was removed in the mined coal.

Data from Russia (Tsibulski 1995) indicates that the balance of methane emissions from coal seams and enclosing rocks is distributed as follows:

60% emitted to atmosphere from mines together with ventilation air
12% captured in mines and if not utilised then also emitted
15% emitted to atmosphere from coal extracted to the surface
13% remains in the seam and surrounding rock

Firedamp may be removed before the mining of a coal seam (pre-drainage) or as a consequence of mining (post-drainage). The latter approach is likely to be the most common.

3.4.1 Post-drainage Technologies

Cross-measures Methane Drainage
Boreholes are drilled at an angle above, and sometimes below, the mined out area, which collapses as the coal is removed. The boreholes are drilled close to the coalface and linked to a common pipe range. Suction is applied to the pipe range to draw the gas to a discharge point. Depending on circumstances and geology, 35% to 75% of the total gas released in an underground district can be captured at purities ranging from 30% to 70%. Higher purity gas is generally not available.

Surface 'Gob' Well Post-drainage
This technology is well established in the US. Gas is drained via surface boreholes from the de-stressed zone above a caving 'long-wall' face. The gas produced is generally of high purity. The principle disadvantage is high drilling costs and surface environmental planning restrictions.

Other methods of post drainage include Super-Adjacent Drainage Heading (Sewer Road) and Super Adjacent Guided Long-hole. Both methods involve driving long boreholes or roadways adjacent to the worked coalface (typically with 30m to 40m). The applicability is very much dependent on local geology.

3.4.2 Pre-drainage Technologies

In-seam Boreholes
This requires drilling boreholes parallel to the undisturbed coalface. The success of this technique depends on the permeability of the coal and the gas pressure. The higher the permeability and gas pressure, the greater the efficiency.

Hydrofracced Surface Boreholes

This technique involves hydraulically fracturing a sequence of productive horizons, injecting sand into the fractures and connecting the fractures to a well head assembly. Gas and other fluids occupy the sand-filled fractures and enter the well head assembly without encountering excessive resistance. The technique has been applied in the US, but is also very dependent on geology.

3.4.3 Extracting Pollutants from the Ventilation Air

Besides active drainage of gas, removal also occurs as a result of the ventilation of the mine. Using the ventilation air as feed air for boilers or engines may control organic compounds associated with ventilation air. Liquefaction of gases, catalytic or biological oxidation are generally inappropriate for low concentrations of organic compounds found in ventilation air.

3.4.4 Utilisation of Firedamp

Reducing Emissions by Flaring

Flaring is not a common method for controlling firedamp, since to practice this safely is often prohibitively expensive.

Reducing Emissions by Using Gas as a Fuel

This is not a new concept. Since recovering combustible material from ventilation air is expensive, the technique applies primarily to actively drained firedamp. Whether or not firedamp is used as a fuel depends primarily on financial considerations, particularly if ensuring a continuous supply requires backup fuels such as Liquid Petroleum Gas, and if competitor fuels are readily available.

4 SIMPLER METHODOLOGY

The simpler methodology involves the application of a general emission factor to an appropriate activity statistic for each of three categories:

- underground coal mine
- open coal mine
- post mining treatment and storage.

5 DETAILED METHODOLOGY

This requires data to be collected for each major coalfield. Specific emission factors for each field are obtained primarily by measurement or inferred from related data from similar fields. The field specific emission factors are used to derive field specific emissions.

Within the detailed methodology data on emissions from individual mines needs to be obtained. Emission determination can be performed using specific emission factors and data on the extraction volume, emission measurements, data on methane intake in the degassing units and the volume of the "whistler" from the de-methaning systems.

6 RELEVANT ACTIVITY STATISTICS

For the simpler methodology the relevant activity statistic is total mass of coal produced by underground mining and the total tonnage of coal produced by opencast mining.

For the more detailed approach, the activity statistic is the tonnage of coal produced from regions or coalfields where each available emission factor can be applied.

7 POINT SOURCE CRITERIA

The underground coalmines can be considered as point sources if the relevant site-specific data are available. It can be necessary in the case the modelling of pollutants dispersion in local or regional scale.

The open-cast mining should be considered as area sources due to large area covered by coal extraction activities.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

8.1 Simpler Methodology

The IPCC Guidelines for National Greenhouse Gas Inventories give a comprehensive review of emission factors derived from measurements and modelling studies.

The default Emission Factors, to be used when no better data is available, are as follows:

<u>Mining Activities</u>	
Deep-mine coal - low methane	10 m^3/Mg coal produced
Deep-mine coal - high methane	25 m^3/Mg coal produced
Opencast-mine - low methane	0.3 m^3/Mg coal produced
Opencast-mine - high methane	2.0 m^3/Mg coal produced
<u>Post mining activities</u>	
Underground coal mine - low methane	0.9 m^3/Mg coal produced
Underground coal mine - high methane	4.0 m^3/Mg coal produced
Opencast-mine - low methane	0.0 m^3/Mg coal produced
Opencast-mine - high methane	0.2 m^3/Mg coal produced

Emission factors relate to methane only. No data quality is given, although the default emission factor is based on a number of measurements, the variation is large. Use of the default emission factors would result in an estimate of data quality D.

Selection of high or low methane emission factor depends on the results of measurement data carried out at selected coalfields. If no data are available then the higher emission factor should be used.

According to information from Russia (Tsibulski 1995) there exists a strong time dependency of emission factors for post mining activities. The above emission factors for post-mining activities relate to combined storage and transport.

There are limited data available on the components of firedamp other than methane. A default profile is given in section 9. This suggests that the maximum concentrations of components other than methane are:

NMVOC 8% ethane (by volume), 4% propane (by volume)
CO_2 6% (by volume)

If 1m^3 methane has a mass of 680g, then
0.08 m^3 ethane has a mass of 102g

0.04 m^3 propane has a mass of 74.8g

0.06 m^3 carbon dioxide has a mass of 112.2g

No information is available on the accuracy or uncertainty of this data and so the data quality is E.

8.2 Detailed Methodology

The range of emission factors is refined, based on country specific data, and where possible mine-specific data. IPCC (1995) gives the following country specific data:

Country	**Emission factor m^3/Mg**
Former Soviet Union	17.8 - 22.2
United States	11.0 - 15.3
Germany	22.4
United Kingdom	15.3
Poland	6.8 - 12.0
Czech Republic	23.9
Australia	15.6

The following table contains emission data from Russia (Tsibulski 1995) on the main gases from coalmines. Methane emissions data were obtained on the basis of the average natural methane content of a coal seam and the quantity of coal extracted by underground mining. Natural methane content of a seam refers to the amount of methane contained in a virgin seam.

Coal Field	Average Natural Methane Content of Seams, m^3/t	Total Methane Resources, billion m^3	Number of mines	Emission of Fire-damp, billion m^3/year	
				CH_4	CO_2
1	17	13186	67	1381	257
2	8	4	28	20	90
3	18	1962	18	794	66
4	6	5.4	10	71	38
5	15	10	14	5	27
6	6	9	2	11	3.5
7	18	122.4	1	2	4
8	18	41382	1	0.2	0.3
9	10	12	2	0.1	10
10	10	142.5	1	0.1	2.5
11	12	8410	2	0.8	0.5
12	10	190	2	2	9
13	12	296	1	0.1	0.4
14	13	132	2	1.5	2
15	9	96	13	15	19
16	12	18	11	30	20
17	9	2	12	6.5	8.5
18	8	6	4	1.7	0.9

The following table contains average emission factors from Poland (Gawlik 1994) and Czech Republic (Fott et al.1998)

Compound	**Plant type**	**Emission factor m^3/Mg**	**Data quality**	**Abatement type**	**Abatement efficiency**	**Country**	**Ref**
CH_4	underground mining	6.01	A			Poland	[5]
CH_4	underground mining	17.6	A			Czech Republic	[6]
CH_4	post mining treatment and storage	1.55*	B			Poland	[5]
CH_4	open cast mining	0.019	B			Poland	[5]

* refers only to hard coal (for open cast mining the proposed emission factor = 0 m^3/Mg)

The detailed methodology also takes into account the use of firedamp as a fuel.

9 SPECIES PROFILES

The following profile of firedamp has been presented in a paper to the UK Watt Committee (Williams 1993).

Species	% content
Methane	80 - 95%
Ethane	0 - 8%
Propane and Higher Alkanes	0 - 4%
Nitrogen	2 - 8%
Carbon Dioxide	0.2 - 6%
Argon	trace
Helium	trace
Hydrogen	trace

The quality of this data is not known. It is assumed that % content relates to volume to volume.

Profiles from Russia (Tsibulski 1995) are as follows:

Mine	H_2	CH_4	C_nH_{2n+2}	CO_2	N_2	O_2
1	-	62	0.31	1	31.6	5.1
2	0.24	89.6	5.16	0.1	4.3	0.3
3	0.07	60.7	3.22	1.2	28.4	6.4
4	-	34.7	0.58	0.9	51.5	12.3
5	-	77.2	0.06	0.5	17.6	4.7

10 UNCERTAINTY ESTIMATES

10.1 Methane

Uncertainty in the activity statistics is very low since national data on tonnage of coal produced is generally considered to be very accurate. Uncertainty in the default emission factors for the simpler methodology is high given the range of emission factors in the data, approximately +/- 50%. Uncertainty in the emission factors for the detailed methodology is likely to be much less, in some cases less than +/- 25%.

10.2 Other components

Uncertainty for components other than methane is very high, due to the lack of data on the composition of firedamp. Uncertainty is considered greater than a factor of 2.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

The priority area for improvement is to provide accurate information on the composition of firedamp, particularly the light hydrocarbon content. This is likely to vary considerably between coalfields.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

Desegregation should be based on the information about territorial units in which the processes occur, and on the production of coal per given territorial unit.

13 TEMPORAL DISAGGREGATION CRITERIA

It may be assumed that emissions occur over 24 hours and consistently throughout the year.

14 ADDITIONAL COMMENTS

No additional comments.

15 SUPPLEMENTARY DOCUMENTS

The IPCC Guidelines for National Greenhouse Gas Inventories should be referred to when estimating emissions.

16 VERIFICATION PROCEDURES

Verification is primarily through provision of national measurement data at representative coalfields. In addition, the validity of measurements can be gauged through comparison with results form other countries.

17 REFERENCES

[1] IPCC (1995) Guidelines for National Greenhouse Gas Inventories. Greenhouse Gas Inventory Reference Manual.

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18 BIBLIOGRAPHY

No additional documents.

19 RELEASE VERSION, DATE AND SOURCE

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