SNAP CODE: **040502**

SOURCE ACTIVITY TITLE: **PROCESSES IN ORGANIC CHEMICAL INDUSTRIES (BULK PRODUCTION)**
Propylene

NOSE CODE: **105.09.51**

NFR CODE: **2 B 5**

1 ACTIVITIES INCLUDED

Propylene is produced by thermal cracking of nafta fractions.

2 CONTRIBUTION TO TOTAL EMISSIONS

The NMVOC emissions of propylene plants according to Corinair 90 were in 1990 0.01% of the total NMVOC emission in the reporting countries.

Table 2.1: Contribution to total emissions of the CORINAIR90 inventory (*28 countries*)

Source-activity	SNAP-code	Contribution to total emissions [%]							
		SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
Propylene	040502	-	-	0.2	-	-	-	-	-

0 = emissions are reported, but the exact value is below the rounding limit (0.1 per cent)
- = no emissions are reported

This activity is not believed to be a significant source of $PM_{2.5}$ (as of December 2006).[1]

3 GENERAL

3.1 Description

The feed is preheated in heat exchangers and brought to the reaction temperature of 750 - 850° Celsius by adding hot products and steam to the reaction furnace. Additional steam is added to dilute the reaction mixture. The residence time is kept short (about 0.1 sec.) to limit side reactions (cokes formation).

After the reaction the gas mixture is quenched with cold oil, which in turn is used to produce steam. The oil gas steam mixture is separated in different fractions in a rectification section. In several steps the most important products of the mixture are separated. The low boiling

[1] Updated with particulate matter details by: Mike Woodfield, AEA Technology, UK, December 2006

products ethylene, propylene and the butylenes are separated after drying, compression and distillation.

After separation from the reaction mixture, ethane and propane are recycled to the reaction furnace feed, methane is used as fuel gas and hydrogen is used for hydrogenation (of acetylene).

The C-4 mixture is used as feed for the butadiene production.

The typical feed (ethane to heavy petroleum distillates) results in a production of about 36% ethylene, 13% propylene, 8% butylenes and 7% aromatics.

3.2 Definitions

Not relevant

3.3 Techniques

See section 3.1.

3.4 Emissions

The major emissions to the air are CO2, NOx, CO and hydrocarbons. The first three compounds are produced during the combustion of fuel gases in the reaction furnace, the hydrocarbons are mostly emitted due to leakage and flaring of the residual gases.

For the Netherlands all cracking processes together produce 4000 ton of VOC's per year. Propylene production is estimated by a proportional share, being 13%, of the total VOC emission. This emission, 520 ton, is related to a production capacity of about 975 kton propylene per year and a realized production of about 870 kton propylene per year.

Emissions can be subdivided as follows [1]:

leakage losses from appendages, pumps, etc.	72%
flaring, disruptions	18%
losses due to storage and handling	1%
combustion emissions	5%
other process emissions	4%

About 73% of the VOC emissions can be considered as production independent (leakage etc. plus losses due to storage etc.), but process operation time dependant (i.e. production capacity dependant). The other 27% is production dependant.

3.5 Controls

The losses due to leakage can be limited by use of certain types of seals and application of double seals near pumps.

4 SIMPLER METHODOLOGY

Use of a default emission factor for the propylene production emissions. The amount of emitted VOC is directly related to the propylene production. For the Netherlands, 4000 ton VOC emission related to the thermal cracking activity, 13% propylene in the thermal cracking product, and 870 kton propylene produced this gives a default emission factor of 0.6 ton VOC/kton propylene produced. .

5 DETAILED METHODOLOGY

A more detailed methodology would be using emission factors for each piece of equipment, like valves, flanges, etc.The total emission factor for the plant can be calculated by multiplying each equipment emission factor by the number of that type of equipment. So, for this method it is necessary to know how many valves etc are present in the plant.

In a Canadian study [2] the use of this methodology instead of the simpler one resulted in a considerably lower estimate of the process emissions.

6 RELEVANT ACTIVITY STATISTICS

Relevant statistics are the production capacity for propylene and the realized propylene production. Table 6.1 lists propylene capacity and Table 6.2 propylene production in several countries and regions.

Table 6.1: Propylene capacity in some regions for 1990 or 1991

Region	ktons/y	source	year
Western Europe	9400	EurChemNews 27/4/92	1990
World	36600	EurChemNews 27/4/92	1991

Table 6.2: Propylene production in some countries and regions for 1990

Country/Region	ktons/y	source
Australia	608	Chem&EngNews 29/6/92
Canada	765	Chem&EngNews 29/6/92
France	1433	Chem&EngNews 29/6/92
Germany, West	1829	Chem&EngNews 29/6/92
Japan	4215	Chem&EngNews 29/6/92
Taiwan	398	Chem&EngNews 29/6/92
U.K.	750	Chem&EngNews 29/6/92
U.S.A.	9918	Chem&EngNews 29/6/92
U.S.S.R.	1366	Chem&EngNews 13/4/92
Western Europe	8800	EurChemNews 27/4/92
Western Europe	6880	UN Statistics 1990

Table 6.3: Propylene production in 2004 (according to the 2004 World Petrochemical Production Report)

	Asia	Western Europe	North America	South America
Propylene	12.969	15.123	16.711	1.852

7 POINT SOURCE CRITERIA

Propylene plants can be considered as point sources.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

As stated in section 4, an overall VOC emission factor for the propylene production in the Netherlands is 0.6 ton VOC per kton propylene produced.

Based on the data presented in section 3.4 and an propylene percentage of 13 of the product from the average feed (sections 1, 3.1) the emission factor of VOC for the propylene production (without taking notice of the other products) can be estimated in more detail as follows:

1 0.389 ton VOC/kton propylene production capacity (leakage and losses).
Namely, 0.13 * 0.73 * 4000 ton VOC per 975 kton propylene production capacity for leakages and losses during handling and storage (together 73% of emissions).

2 0.162 ton VOC/kton propylene produced (combustion, flaring, other processes).
Namely, 0.13 * 0.27 * 4000 ton VOC per 870 kton propylene produced.

Part of these emissions are already dealt with under other SNAP codes (combustion and flaring): 0.138 ton VOC/kton propylene produced.
Namely, 0.13 * (0.18 + 0.05) * 4000/870.

For propylene the same emission factors are used as for ethylene (see ethylene for other factors) except in the 1985 NAPAP Emission Inventory (0.45 kg/ton for propylene and 0.40 for ethylene). Following this approach the World Bank report (1998) would give 0.6 to 10 kilograms per metric ton propylene produced, depending on the quality of the abatement methods applied.

9 SPECIES PROFILES

Tables 9.1 and 9.2 list the VOC profile respectively for the different sources and the overall profile.

Table 9.1.: The composition of the VOC emissions for the different sources is [2] :

	methane	ethylene	propylene	benzene	others HC's
leakage loss	70%	5%	3%	1%	21%
flaring and disruptions	10%	40%	25%	1%	24%
storage and handling loss	0%	0%	0%	1%	99%
combustion	75%	10%	0%	1%	14%
other process emissions	70%	5%	3%	1%	21%

Table 9.2.: The overall VOC emission profile for plants

	TNO ER [2]
Methane	58.8%
Ethylene	11.5%
Propylene	6.8%
Benzene	1.0%
other HC's	22.0%

10 UNCERTAINTY ESTIMATES

The data on which the proposed emission factors are based are rather old. They should only be used as default factors with the appropriate uncertainty.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

- The emission factors given are mainly based on internal information of producers gathered by TNO during the emission inventory in the Netherlands. Comparison with data from other countries should improve the quality.
- These data so far assume an average feed and an average composition of the production process in which besides propylene also a wide range of other commodities are produced.
- The leakage losses are estimated with emissions factors used for the chemical industry as a whole. No subdivision within the chemical industry is made.
- The flaring emission is based on an assumed combustion percentage. The measurement of the amount of gas flared is inaccurate and in most cases only roughly estimated..
- One factor is used for all countries. It would be more accurate to use a different factor for each country or each group of countries.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

Not relevant.

13 TEMPORAL DISAGGREGATION CRITERIA

The propylene plants are operated in continuous flow, thus no variation in emissions diurnally or seasonally is expected to occur.

14 ADDITIONAL COMMENTS

No additional comments.

15 SUPPLEMENTARY DOCUMENTS

Detailed reports on refinery processes can be found on the sites of for instance USEPA and UNECE.

16 VERIFICATION PROCEDURES

Verification of the emissions can be done by comparing with measurements in the individual plant or by setting up a mass balance over the entire plant.

17 REFERENCES

1 Communication with propylene producing company in the Netherlands (1992).
2 Emissions of Volatile Organic Compounds from selected organic chemical plants, B.H. Levelton & Associates Ltd., 1990.

3. World Bank group Pollution prevention and abatement Handbook Petrochemicals Page 371 and 372 (1998)

18 BIBLIOGRAPHY

- Kirk-Othmer, Encyclopedia of Chemical Technology, Volume 14, 4th Edition (1995).
- Winnacker-Küchler, Chemische Technologie, Organische Technologie I, Band 5, 4. Auflage (1982) (in German).
- International Petrochemical Information Forum : 2004 World Petrochemical Production Report

19 RELEASE VERSION, DATE AND SOURCE

Version : 1.3

Date : September 2006

Source : J.J.M. Berdowski, W.J. Jonker & J.P.J. Bloos
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20. POINT OF ENQUIRY

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