



EUREKA

# **EBSOM**

## **European Benchmark Study On Maintenance**

**EUREKA PROJECT EU.724,  
MAINE/EBSOM**

**December 1993**

**Kunnossapitoyhdistys ry, KPY  
Föreningen Underhållsteknik, UTEK  
Norsk Forening for Vedlikehold, NFV  
Den Danske Vedligeholdsforening, DDV**

# **EUREKA**

## **European Benchmark Study on Maintenance**

### **EBSOM - EU 724**

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## **BACKGROUND AND SUMMARY OF RESULTS**

The project was started at the initiative of Den Danske Vedligeholdelsesforening (DDV) (The Danish Maintenance Association) in connection with EUREKA-MAINE network activities.

Danish participation in the Eureka project MAINE/EBSOM with the label EU724 was notified at the Eureka High Level Group meeting in Tampere on 6 February 1992. After that meeting a cooperation agreement with Finland and Sweden was established, whereas Norway contributed on a voluntary basis, i.e. without EUREKA funding.

Denmark was the liaison country and as such responsible for following up on the project and submission of progress reports to the High Level Group. Mr. Poul Knudsen, National Project Coordinator of the EUREKA office of the National Agency for Development of Trade and Industry, Denmark, has been in charge of the administrative project management and coordination, and Crone & Koch DV A/S (Steen Schrøder and Per Vinther) have taken care of the technical project management.

The Finnish project was started by Kunnossapitoyhdistys ry (the Finnish Maintenance Society) and its Research Committee (Harri Hajunpää, Rauno Kuoppala, Ilkka Niemelä, Veli Siekkinen and Hannu Tirinen) was responsible for organising the practical part of the research. The National High Level Group for the project was: Jouko Kuivalainen, Kari Norberg and Esa Leclin. Mr. Harri Hajunpää was the National Project Coordinator. Outokumpu Mining Services Oy took care of the technical project management. Prof. Veli Siekkinen made the numerical analysis of the inquiry answers.

The contribution from Sweden was made by Föreningen Underhållsteknik, UTEK (The Swedish Maintenance Society), whose EBSOM Group consisted of Olof Malmholt, Leo Hagberg, and Benny Halldin. Närings- och teknikutvecklingsverket, NUTEK, (The Swedish Agency for Development of Trade and Industry) supported the project financially.

The participants from Norway were Per Schjølberg and Ståle Hunstad of SINTEF (The Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology, and NFV (The Norwegian Society of Maintenance Engineers).

The project was scheduled for summer 1992 to autumn 1993, with the following activities as given in the project description:

## **"I. Project Description**

The aim of EBSOM is to establish a trade-by-trade overview of maintenance methods and related results and thus to give individual companies a basis for pinpointing areas in which their efficiency and competitiveness can be improved.

The project is organised in the following modules:

### **1. Definition Phase**

To be implemented by the participants in each country, with regular coordination of results and progress.

- 1.1 Identification and review of previous benchmark studies.
- 1.2 Identification and grouping of practical indicators for measuring maintenance efficiency.
- 1.3 Identification and description of methods (organisational, technical and administrative) of maintenance management.

### **2. Implementation Phase**

- 2.1 Drawing up of a questionnaire.
- 2.2 Selection of companies to be included in the survey.
- 2.3 Sending out and collection of questionnaires.

### **3. Full exploitation (Analysis and reporting)**

- 3.1 Statistical processing of data.
- 3.2 Categorisation of data by country, trade, methods and results.
- 3.3 Drawing up of key figures and comparison with previous surveys.
- 3.4 Report on the project containing key figures and guidelines on where and when it appears worthwhile to rationalise maintenance.



## **II Technological Developments**

The intention of the EBSOM project is that the result - key figures for maintenance - should be used by companies to:

- pinpoint new areas of effort for maintenance
- compare their own efforts and results with those of others
- establish new maintenance goals.

In addition, the key figure report is to be used to clarify the question of which maintenance methods - organisational, technical and administrative - are most effective in the various countries and trades. In this way the report can function as guidelines for maintenance work in the individual companies."

### **Summary of results from the EBSOM project**

#### **Key figures for maintenance**

This report constitutes a tool which can be used by individual companies to compare their own efforts with others within the same trade - and thus provide inspiration for further development within maintenance.

The analysis of the results has shown certain tendencies which can be used, although with caution, as a rough framework for development within maintenance.

For the following reasons, caution should be exercised when comparing key figures for direct maintenance costs:

- The basis differs - the age and quality of machinery and buildings differ.
- Bookkeeping/accounting practice differs from one company to another
- The interpretation/use of principal maintenance concepts differs
- Cost of unforeseen stoppages differs
- Different external requirements - for example, concerning safety
- The environment - corrosion, dust etc. - differs from one process to another
- Different attitudes to attrition/decrease in value
- Different attitudes to service level
- The forms of operation - number of shifts, production technology, etc. differ

These differences are thus also reflected in a considerable spread in the key figures of the analysed companies.

## **Areas of effort for maintenance**

### **General**

In the course of this project a need has been established for a standardisation of terminology and a need for guidelines for structuring maintenance data both within the individual countries and across borders.

It would also be useful to establish a methodology for determining the benefits of maintenance with respect to availability, product quality, flexibility, supply safety, safeguarding of value, use of resources and safety of surroundings, staff and installations, etc.

### **In the individual companies**

The companies' responses to the questionnaires and the analysis of the results show a need to stress the following important areas of effort for development of the maintenance function:

#### **Organisation:**

- Improve the production staff's qualifications regarding maintenance and involve them in maintenance work
- Improve the production management's and the maintenance staff's qualifications regarding maintenance
- Improve the production management's knowledge of maintenance
- Formulate clear goals (regarding desired benefits and costs) for maintenance - and perform regular follow-up on fulfilment of goals by using, for example, key figures for benefits and costs

#### **Installations:**

- Improve the maintenance function's influence in the design, specification and purchase phases
- Improve the maintainability of installations

#### **Distribution of resources:**

- Improve condition-based maintenance
- Improve preventive maintenance

#### **Planning and control:**

- Improve the planning and preparation of maintenance jobs
- Extend the use of computer-based maintenance systems

A number of the above areas of effort are included in the activities of the EUREKA-MAINE project EU1073, EUROGUIDE.



**EUREKA**

**European Benchmark Study on Maintenance**

**EBSOM - EU 724**

**Chapter 1**

# **DDV analysis**

**(The Danish Maintenance Association)**

**Maintenance in Industry 1991**



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1. Average values for individual industrial sectors 1991
2. Trends in key figures
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## 1. PREFACE

Den Danske Vedligeholdelsesforening (DDV) (The Danish Maintenance Association) is carrying out the EUREKA/MAINE project EBSOM (European Benchmark Study on Maintenance) together with maintenance associations in Sweden, Norway and Finland.

The intention of the EBSOM project is that the result - key figures for maintenance - should be used by companies to:

- \* pinpoint new areas for maintenance action
- \* compare their own efforts and results with those of others
- \* establish new maintenance goals.

In addition, the EBSOM project is to be used to clarify the question of which maintenance methods - organisational, technical and administrative - are most effective in the various countries and trades.

As part of the EBSOM project, the DDV Technical/Finance Committee has carried out a questionnaire analysis on industrial maintenance 1991.

The results of the Danish questionnaire analysis are presented in this report, which contains partly key figures (section 3), and partly an analysis of maintenance methods to determine the most effective with respect to minimising direct maintenance costs (sections 4 and 5).

We hope and believe that this report will help to generate debate and development in the field of maintenance generally and at individual companies.

DDV Technical/Finance Committee

1 October 1993

The members of the specialist committee were:

Torben Andreasen, Cheminova Agro A/S  
Finn Djurhus, Dansk Teknologisk Institut  
Victor Källstrøm, Rockwool A/S  
Erik Larsen, FAXE Bryggeri A/S  
Søren Madsen, Tuborg Bryggerierne A/S  
Carsten Morild, Aalborg Portland  
Hans Jørgen Pedersen, BASF Vitaminfabrik A/S  
Lars Ryø, Hydro Aluminium Automotive  
Per Vinther, Crone & Koch DV A/S

The numerical data were processed by:  
Crone & Koch DV A/S

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## 2. THE BASIS OF THE DDV ANALYSIS

The analysis made by DDV (*Den Danske Vedligeholdsforening* - The Danish Maintenance Association) describes maintenance in industry as it appears from the companies' responses to the questionnaire attached as Annex 3.

The analysis is based on responses from 43 industrial companies. These companies account for approx. 12% of the total turnover in Danish industry and approx. 8% of industrial employment.

It is primarily large and presumably well organised companies that have returned the questionnaire.

As will be seen from the following table of responses given as percentage of sectoral turnover, the representative value of the figures varies from sector to sector:

<u>Industrial sectors</u>		<u>Response Percentage</u>
31 Manufacture of food, beverages, tobacco	(FBT)	12 %
32 Textiles, clothing, leather industry	(TCL)	3 %
33 Manufacture of wood products, incl. furniture	(WP)	4 %
34 Manufacture of paper, printing, publishing	(PPP)	3 %
35 Chemical and petroleum industries	(CP)	36 %
36 Non-metallic mineral products	(NMP)	16 %
37 Basic metal industries	(BM)	0 %
38 Manufacture of fabricated metal products	(FMP)	5 %
39 Other industrial sectors		0 %

The data for the average company have been processed on the basis of 43 companies in accordance with the distribution given above.

The classification of industrial sectors used is the International Standard Industrial Classification of all economic activities (ISIC 68).

No results have been published from sectors in which less than four companies have returned the questionnaire.

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### 3. KEY FIGURES FOR MAINTENANCE

#### 3.1 Maintenance costs

Maintenance costs include wages and salaries, spare parts, materials, external services, administration, etc. However, it has not been possible to include costs for production losses or decrease in value caused by insufficient maintenance.

For the following reasons, caution should be exercised when comparing key figures for direct maintenance costs:

- The basis differs - the age and quality of machinery and buildings differ.
- Bookkeeping/accounting practice differs from one company to another
- Cost of unforeseen stoppages differs
- Different external requirements - for example, concerning safety
- The environment - corrosion, dust etc. - differs from one process to another
- Different attitudes to attrition/decrease in value
- Different attitudes to service level

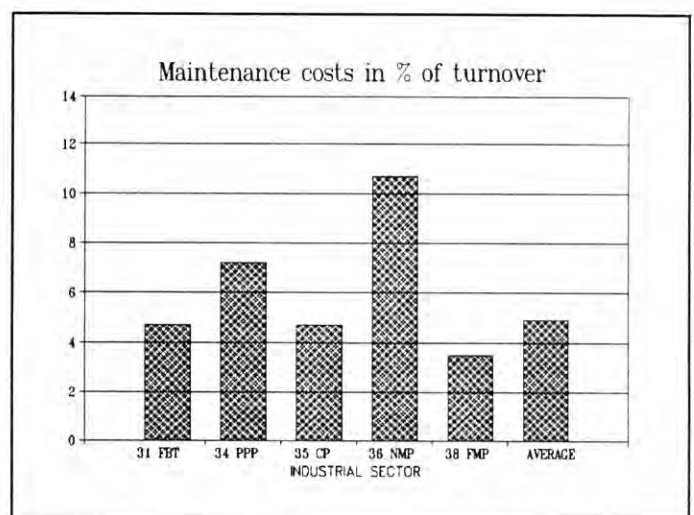
These differences are thus also reflected in a considerable spread in the key figures of the analysed companies.

Minimum, average and maximum values for key figures within the various sectors are shown in Annex 1.

#### Maintenance costs in % of turnover

On average, 4.9% of the companies' turnover in 1991 was spent on maintenance - the same percentage as in 1981.

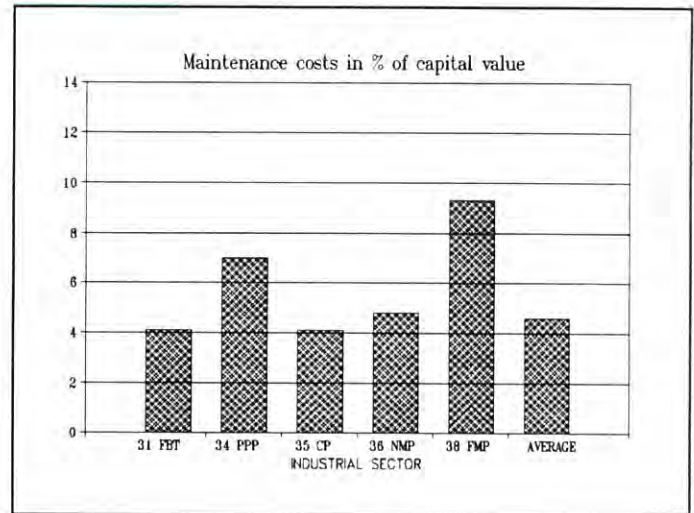
This seems to be a coincidence, since - as will be seen from Annex 2 - maintenance costs' share of turnover has increased in all industrial sectors participating in the analysis.





### Maintenance costs in % of capital value

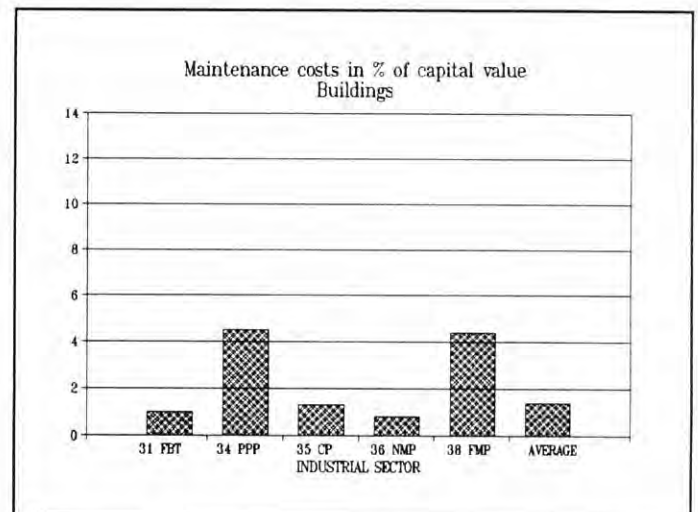
On average, maintenance costs constituted 4.6% of the capital value (replacement cost) in 1991, which is an increase of 0.6% compared with 1981.



### Buildings

Maintenance costs for buildings averaged 1.4% of the buildings' capital value, which is 0.3% lower than in 1981.

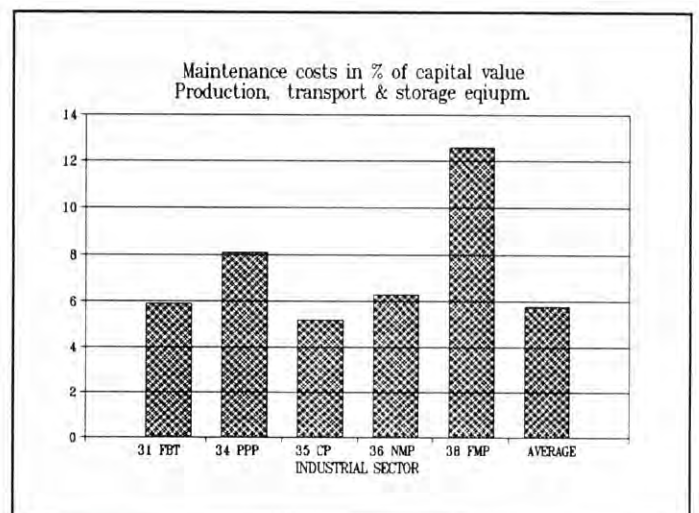
On average, the companies spent DKK 119.- /m<sup>2</sup> on building maintenance.



### Production, transport and storage equipment

Maintenance costs for production, transport and storage equipment averaged 5.8% of the capital value - an increase of 0.9% in relation to 1981.

In the analysed industrial sectors, the average service age of production plant is 10 - 13 years.



### Rolling stock

Maintenance costs for rolling stock averaged 8.3% of the stock's capital value.

The average age of the rolling stock is 4 - 6 years in the analysed industrial sectors.

### 3.2 Spare parts

The average rate of stockturn increased from 1 in 1981 to 1.3 in 1991.

Similarly, the spare part stock's share of the capital value increased from 1% in 1981 to 1.4% in 1991.

## 4. MAINTENANCE METHODS

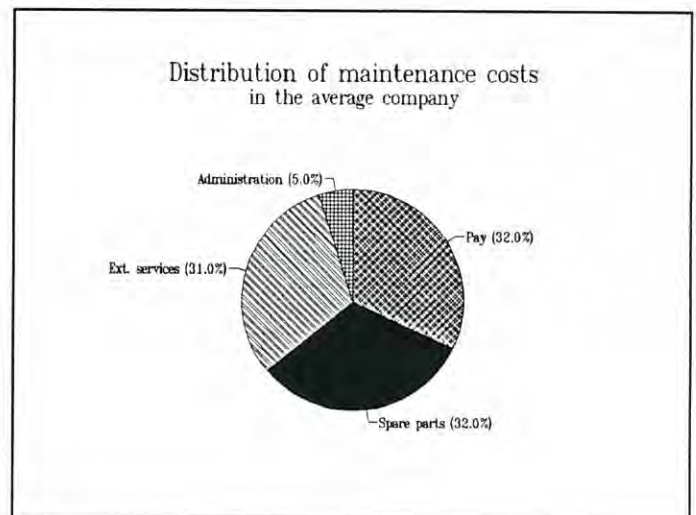
### 4.1 Distribution of maintenance costs

#### Pay, external services, spare parts and administration

In the average company maintenance costs are distributed as shown in the figure with small variations from one sector to another.

The non-metallic mineral products industry spends approx. 45% of its maintenance costs on spare parts.

The paper, printing and publishing industries spend relatively more on wages for own personnel and correspondingly less on external services.



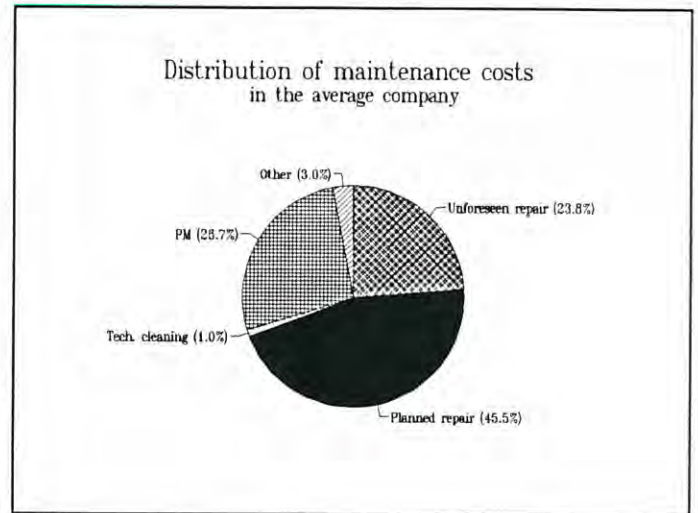


Unforeseen and planned repairs, preventive maintenance, etc.

Maintenance costs in the average company are distributed as shown in the figure with variations from one sector to another.

On average, the non-metallic mineral products industry, the paper, printing and publishing industries, and the fabricated metal products industry, spend 14% of their maintenance costs on preventive maintenance compared with the food, beverages and tobacco industries, and the chemical and petroleum industries, which, on average, spend approx. 30% on preventive maintenance.

40% of the companies spend between 15 and 40% of their maintenance costs on unforeseen repairs - and in these companies maintenance costs as a percentage of capital value are lower than in the other companies.



#### 4.2 Objectives and policies

Approximately half of the companies have formulated and documented objectives and policies for maintenance - and in these companies maintenance costs as a percentage of capital value are lower than in the other companies.

Maintenance objectives include:

- Safety
- Environment
- Condition of plant and equipment
- Maintenance costs
- Hours of operation

Maintenance policies include:

- Planning and systematisation in maintenance
- Preventive maintenance
- Training
- Distribution of tasks and responsibility
- Use of NDE methods

4.3 Application of key figures

58% of the companies apply key figures for costs to measure and follow up on maintenance activities.

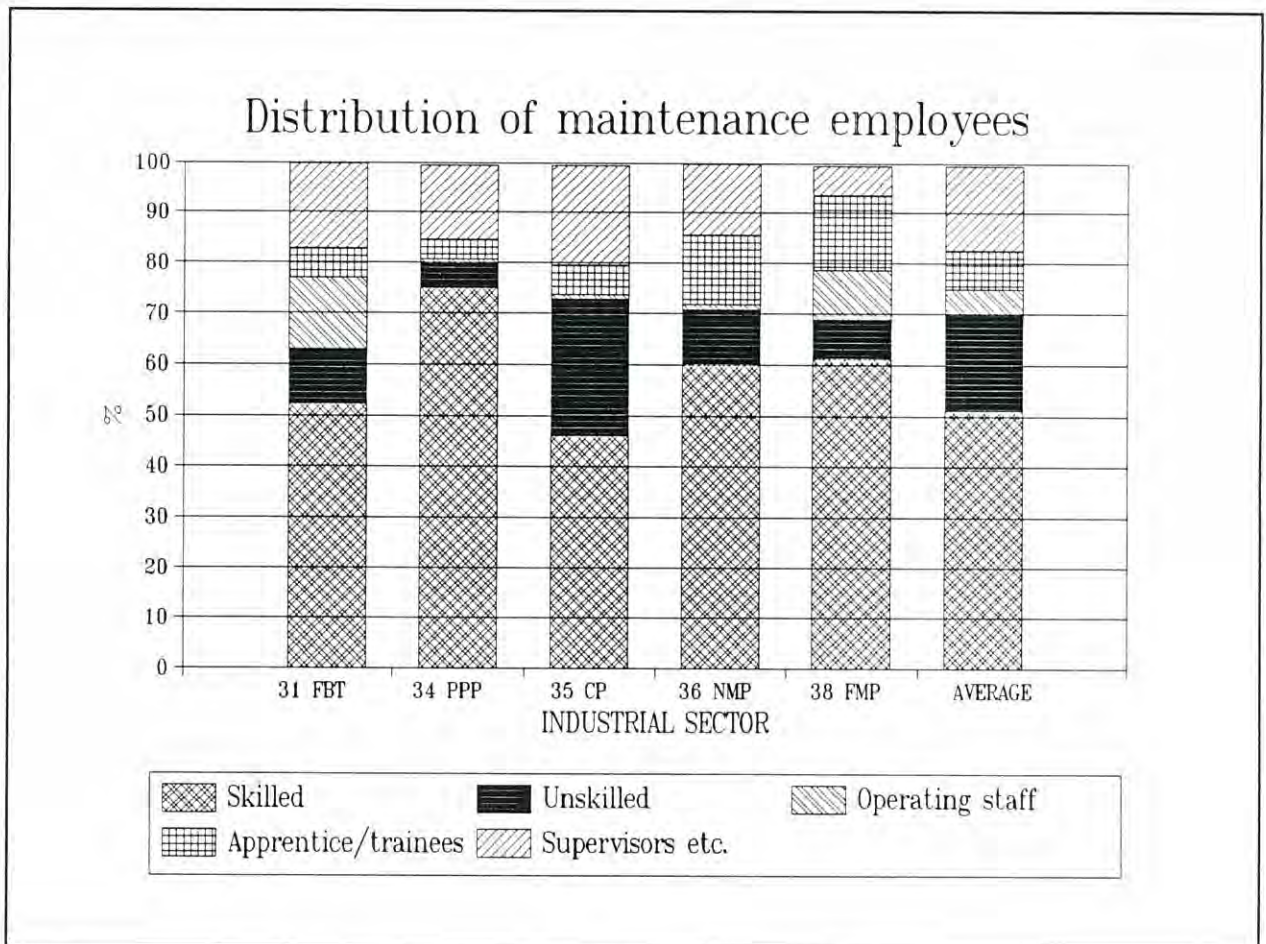
58% of the companies apply key figures for availability to measure and follow up on maintenance activities.

44% of the companies apply key figures for service level.

4.4 Organisation

In 1991, approx. 8% of the employees in the analysed industrial companies worked solely on maintenance.

On average, each supervisor is responsible for 8 maintenance employees.



As will be seen from the above figure, it is almost exclusively within the food, beverages and tobacco industries and within the fabricated metal products industry that operating personnel are engaged in maintenance work.

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44% of the companies have a maintenance manager responsible for maintenance.

In the approx. 20% of the companies with a centralised maintenance function with a maintenance manager and with formulated and documented maintenance objectives and policies, maintenance costs as a percentage of capital value are on average considerably lower than in the other companies.

In 23% of the companies, the production manager is responsible for maintenance - and in these companies the maintenance costs as a percentage of capital value are on average higher than in the other companies.

In 16% of the companies, production and maintenance are integrated - and in these companies maintenance costs as a percentage of capital value are on average higher than in the other companies.

#### 4.5 Training

On average, skilled/unskilled maintenance employees received 26 hours of training in 1991.

The fabricated metal products and the printing and publishing industries spend considerably more hours on training than the other industrial sectors.

In half of the companies, skilled/unskilled maintenance employees receive between 1 and 6 days' training per year - and in these companies the maintenance costs as a percentage of capital value are smaller than in the other companies.

On average, supervisors and other salaried employees within maintenance received 21 hours' training in 1991 - and, here too, the fabricated metal products and the paper, printing and publishing industries spend more hours on training than the other industrial sectors.

In 40% of the companies, supervisors and other salaried employees within maintenance receive between 1 and 5 days' training per year - and in these companies the maintenance costs as a percentage of capital value are on average lower than in the other companies.

#### 4.6 Influence on acquisition and replacement of production plants, building etc.

In 84% of the companies, the maintenance function has a medium to large influence in the design and specification phase.

In the companies where the maintenance function has little influence in the design and specification phase and in the evaluation of tenders the maintenance costs as a percentage of capital value are on average considerably higher than in the other companies.

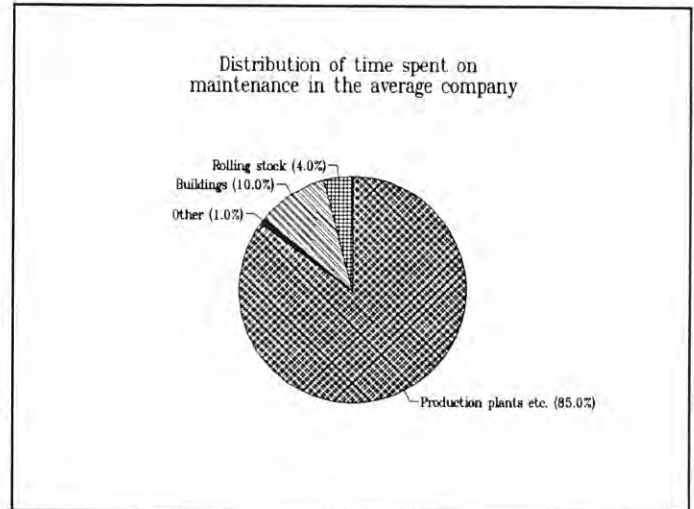
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#### 4.7 Use of internal resources

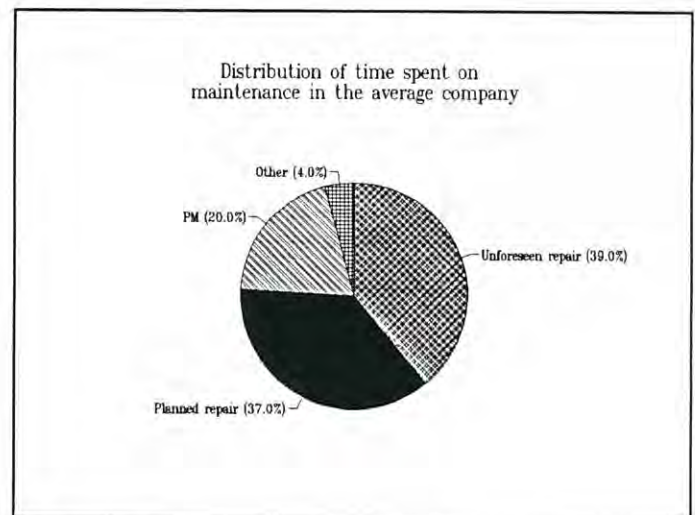
Distribution of time spent on production plant, buildings, rolling stock, etc.

The average time spent by maintenance employees is distributed as shown in the figure with small variations from one sector to another.



Distribution of time spent on unforeseen and planned repairs, preventive maintenance, etc.

The average time spent by maintenance employees is distributed as shown in the figure with big variations from one sector to the other.



The chemical and petroleum industries use primarily their own maintenance staff for unforeseen repairs, whereas the non-metallic mineral products industry primarily use their own maintenance staff for planned repairs.

Preventive maintenance's share of the total time spent on maintenance is approximately the same from one sector to another.

#### 4.8 Planning and control

In the participating companies, planning of preventive maintenance is primarily based on suppliers' directions. However, approx. 45% of the companies use a combination of suppliers' directions, troubleshooting and condition analyses as their planning basis.

Use of computers to control preventive maintenance has increased considerably from 9% in 1981 to 60% in 1991.

In the companies that control work orders and preventive maintenance manually, maintenance costs as a percentage of capital value are on average lower than in the other companies.

Computers are used for job control in all the companies where production and maintenance are integrated.

Use of computers to control spare parts has also increased considerably from 10% in 1981 to 50% in 1991.

25% of the companies do not have any control or registration of spare parts - and these companies have a considerably higher rate of stockturn and a considerably smaller stock of spare parts as a percentage of capital value than the companies that use computers. It is assumed that the reason for this is precisely the lack of registration, so that the spare part stock in companies without control or registration of spare parts is considerably larger than stated in the questionnaires.

Events, spare parts and external services are often registered for individual machines/buildings, whereas pay to own maintenance staff is just as often registered for departments.

The companies using computers to control maintenance record the data in more detail than the other companies.

60% of the companies are certified/or in the process of certification in accordance with ISO 9000 or similar standard, which, among other things, has affected:

- Cooperation between production and maintenance - improved
  - Attention to maintenance - increased
  - Availability - improved
  - Extent of calibration - increased
  - Documentation - improved
  - Inspection and overhaul - must be documented
  - Control - implementation of computer-controlled maintenance
  - Requirements concerning maintenance - increasing
  - Procedures for maintenance - have been drawn up
-

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5. Correlation between methods used and results achieved

Results achieved expressed by key figures for maintenance can be described by:

Direct maintenance costs:

- Maintenance costs as a percentage of capital value
- Maintenance costs as a percentage of turnover
- Maintenance costs per unit produced

Indirect maintenance costs:

- Costs for production losses caused by maintenance as a percentage of turnover
- Deterioration of the condition of buildings and plant - decrease in value in % of capital value

Availability:

- Reliability - supply safety - hours of operation - runfactor
- Downtime for unforeseen stoppages or downtime for planned stoppages

Service level:

- Complaints
- Reaction time - interval from fault reported until repair
- Accident rate
- Absenteeism rate

This analysis has focused on finding correlations between direct maintenance costs and methods used, and one of the things we have found is that maintenance costs as a percentage of capital value are on average lower in companies which:

- formulate and document objectives and policies for maintenance,
- give the maintenance function influence in the design and specification phase as well as in the evaluation of tenders,
- have a centralised maintenance function with a maintenance manager who has formulated and documented objectives and policies for maintenance,
- spend between 15 and 40% of the maintenance costs on unforeseen repairs,
- spend between 1 and 6 days per year on training,
- control work orders and preventive maintenance manually.

Similarly, we have found that maintenance costs as a percentage of capital value are on average higher in companies which:

- have integrated production and maintenance
- have a production manager in charge of maintenance

If you are interested in other correlations than those described above, you are welcome to contact DDV (The Danish Maintenance Association). The number to ring is +45•93•37•40.

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AVERAGE VALUES FOR INDIVIDUAL SECTORS:	31 FBT	34 PPP	35 CP	36 NMP	38 FMP	3 AVRG.
<b>GENERAL:</b>						
Participating companies	9	4	13	4	10	43
Turnover excl. tax + VAT in DKK mio	1341	184	1339	464	511	888
Capital value (insurance value in DKK mio)	1729	189	912	1033	191	776
Distribution of capital value in %:						
A. Buildings	41	31	25	26	39	33
B. Storage, production + transport equipment	55	66	70	65	58	62
C. Rolling stock	2	3	4	3	3	3
D. Other	2		1	6		2
Number of m <sup>2</sup> buildings:	59200	12032	25303	-	25333	30565
Average age of:						
A. Storage, production + transport equipment	13	10	10		11	11
B. Rolling stock	6	4	4	5	6	6
Number of employees (full-time)	770	228	1220	765	689	833
<b>MAINTENANCE COSTS:</b>						
Total maintenance costs in DKK mio	63.6	13.2	64.5	49.5	16.8	43.5
Distribution of maintenance costs in %:						
A. Buildings	11	20	14	4	20	13
B. Storage, production + transport equipment	68	76	84	85	77	78
C. Rolling stock	6	2	1	6	2	3
D. Other	15	2	1	5	1	6
Distribution of maintenance costs in %:						
A. Pay to own maintenance employees	34	55	31	25	36	32
B. Spare parts and materials	30	30	28	45	38	32
C. External services	29	10	38	23	23	31
D. Administration etc.	8	5	3	7	3	5
Distribution of maintenance costs in %:						
A. Unforeseen repairs	17	51	34	12	26	24
B. Planned repairs	45	30	35	70	58	46
C. Preventive maintenance	34	13	28	13	14	27
D. Industrial cleaning	1	2			1	1
E. Other	3	4	3	5	1	3
Distribution of costs for external services in %						
A. Buildings	15	56	48	15	30	35
B. Storage, production + transport equipment	51	35	51	81	64	54
C. Rolling stock	5	6	1	4	5	3
D. Other	29	3			1	8
Value of spare parts stock in DKK mio	13.0	4.8	14.3	35.7	2.7	12.0
<b>ORGANISATION:</b>						
Form of organisation						
A. Centralised	44	100	70	25	50	58
B. Decentralised	33		15	25	40	21
C. Integrated with production	22		15	50	10	16
Manager in charge of maintenance						
A. Maintenance manager	11	50	70	25	40	44
B. Production manager	33		15	50	30	23
C. Technical manager	22	50	8		20	16
% of companies that have formulated and documented maintenance objectives and policies	33	50	70	25	30	46

AVERAGE VALUES FOR INDIVIDUAL SECTORS:		31	34	35	36	38	3
		FBT	PPP	CP	NMP	FMP	AVRG.
Maintenance staff's influence in the design and specification phase:							
A.	Large	78	50	30	50	40	44
B.	Medium	22	25	62	50	30	40
C.	Small		25	8		20	12
Maintenance staffs' influence on evaluation of tenders:							
A.	Large	78	75	31	50	30	44
B.	Medium	22	25	38	50	60	40
C.	Small			31			12
Maintenance staff's influence on installation/running-in:							
A.	Large	78	75	54	75	20	53
B.	Medium	11	25	38	25	60	35
C.	Small	11		8		10	7
Maintenance staff's influence on commissioning/handing-over:							
A.	Large	78	75	69	75	20	60
B.	Medium	22	25	23	25	50	28
C.	Small			8		20	7
Total number of maintenance employees:							
Distribution in %:							
A.	Automatics mechanic	3	3	10	1	8	6
B.	Other skilled employees	49	72	36	59	53	45
C.	Unskilled	11	5	27	11	8	19
D.	Operating staff	14	1	1	1	10	5
E.	Apprentices/Trainees	6	4	6	14	15	8
F.	Supervisors	13	12	9	9	5	10
G.	Other salaried employees	4	3	11	5	1	7
Distribution of time spent by maintenance staff on maintenance in %:							
A.	Buildings	7	6	15	3	10	10
B.	Storage, production + transport equipment	87	90	80	92	84	85
C.	Rolling stock	5	3	4	3	2	4
D.	Other	1	1	1	2	4	1
Distribution of time spent by maintenance staff on maintenance in %:							
A.	Unforeseen repairs	25	35	62	10	31	39
B.	Planned repairs	48	31	18	68	44	37
C.	Preventive maintenance	23	23	17	13	19	20
D.	Other	3	10	3	9	6	4
Time spent on training of maintenance staff - hours per year:							
A.	Skilled and unskilled	1637	1447	922	950	2200	1328
B.	Supervisors and other salaried employees	303	116	286	662	106	260
<b>PLANNING AND CONTROL:</b>							
% of companies using the following parameters in the planning of maintenance:							
A.	Supplier directions	89	75	85	100	90	93
B.	Condition analyses	78	25	85	50	60	72
C.	Official requirements	56	50	85	75	50	67
D.	Downtime and cause of fault analyses	67	75	54	75	40	60
% of companies using computers for registration and control of:							
A.	Basic plant data	44	50	69	50	40	53
B.	Preventive maintenance	56	75	69	75	30	60
C.	Work orders	33	25	54	75	40	46
D.	Maintenance costs	89	50	85	100	70	81
E.	Spare part store	33	25	34	75	50	81
% of companies registering events to:							
A.	Individual machinery/buildings	56	100	77	75	60	72
B.	Groups of machinery/buildings	33			25		9
C.	Departments	11		23		30	16



AVERAGE VALUES FOR INDIVIDUAL SECTORS:		31	34	35	36	38	3
		FBT	PPP	CP	NMP	FMP	AVRG.
% of companies registering pay to own maintenance employees on:							
A.	Individual machinery/buildings	44	50	46	50	20	40
B.	Groups of machinery/buildings				25	10	7
C.	Departments	56	50	54	25	60	51
% of companies registering spare parts on:							
A.	Individual machinery/buildings	33	25	54	75	50	51
B.	Groups of machinery/buildings	44	75	8	25		21
C.	Departments	11		38		30	21
% of companies registering external services on:							
A.	Individual machinery/buildings	56	50	54	75	50	58
B.	Groups of machinery/buildings	22	25	8	25		12
C.	Departments	22	25	38		40	28

**KEY FIGURES:**

% of companies using key figures for costs to measure maintenance activities:							
A.	Maintenance costs/capital value	33		46	25	60	40
B.	Maintenance costs/turnover	22		38	50	20	33
C.	Costs incurred by production losses	33	25	8		30	19
D.	Rate of stockturn, spare parts	22		38	25	20	26
% of companies using key figures on availability to measure maintenance activities:							
A.	Downtime due to unforeseen stoppages	44		15	25	50	28
B.	Downtime for planned maintenance	56	25	30		50	40
C.	Availability of primary production plant	44		46	25	50	40
% of companies using key figures on service level to measure maintenance activities:							
A.	Annual number of complaints	33	25	23	25	60	37
B.	Interval in hours from fault reported to repair	44		23	25	60	37

**KEY FIGURES - TOTAL MAINTENANCE COSTS:**

Maintenance costs as a % of turnover	4.7	7.2	4.7	10.7	3.5	4.9
• Minimum	0.7	1.5	1.0	8.2	0.5	0.5
• Maximum	8.0	26.7	15.5	40.0	8.3	40.0
Maintenance costs as a % of capital value	4.1	7.0	4.1	4.8	9.3	4.6
• Minimum	1.8	1.3	1.8	3.1	1.2	1.2
• Maximum	5.9	12.4	14.3	6.6	50.0	50.0

**KEY FIGURES - BUILDINGS:**

Maintenance costs for buildings as a % of capital value, buildings	1.0	4.5	1.3	0.8	4.4	1.4
• Minimum	0.6	1.4	0.1	0.6	0.4	0.1
• Maximum	2.2	9.1	5.8	2.5	12.5	12.5
Maintenance costs for buildings per m <sup>2</sup> [DKK/m <sup>2</sup> ]	143	223	56		152	119
• Minimum	49	34	11		17	11
• Maximum	384	1292	146		448	1292



AVERAGE VALUES FOR INDIVIDUAL SECTORS:	31 FBT	34 PPP	35 CP	36 NMP	38 FMP	3 AVRG.
<b>KEY FIGURES - PRODUCTION, TRANSPORT AND STORAGE:</b>						
Maintenance costs for production plant as a % of capital value of production plant	5.9	8.1	5.2	6.3	12.6	5.8
• Minimum	2.6	1.1	2.2	3.4	1.4	1.1
• Maximum	10.0	13.6	22.1	10.2	75.0	75.0
External services' share of overall maintenance costs for productions, transport and storage [%]	21.3	4.8	28.9	22.3	19.5	23.3
The wage bill's share of overall maintenance costs for production plant [%]	43.2	67.0	19.9	26.5	40.1	32.2
<b>KEY FIGURES - ROLLING STOCK:</b>						
Maintenance costs for rolling stock as a % of capital value of rolling stock	16.8	5.3	2.8	9.4	9.0	8.3
• Minimum	0.9	3.1	1.5	3.3	0	0
• Maximum	30.9	9.3	40.0	51.1	100	100
<b>KEY FIGURES - SPARE PARTS:</b>						
Rate of stockturn	1.6	1.5	1.2	0.8	3.2	1.3
• Minimum	0.4	1.0	0.6	0.6	0.8	0.4
• Maximum	10.6	2.0	5.8	1.2	13.8	13.8
Value of spare part stock as a % of capital value	0.8	1.7	1.5	2.7	1.3	1.4
• Minimum	0.3	1.5	0.2	1.5	0	0
• Maximum	1.5	1.9	3.3	4.0	1.6	4.0
<b>KEY FIGURES - EMPLOYEES:</b>						
Maintenance employees per 100 employees	12	4	9	14	3	8
Maintenance costs per employee in DKK 1000	83	24	53	83	24	54
Maintenance costs per maintenance empl. in DKK 1000	685	703	585	588	872	637
Maintenance employees per supervisor	5	7	8	9	17	8
Maintenance employees per DKK mio of capital value	0.1	0.1	0.1	0.1	0.1	0.1
Number of hours per year for training per skilled/unskilled employee	28	103	11	16	118	26
Number of hours per year for training per supervisor/salaried employee	19	47	13	58	74	21
Wage bill per maintenance employee in DKK 1000	230	388	179	148	315	205

31. MANUFACTURE OF FOOD, BEVERAGES, TOBACCO

	<u>1981</u>	<u>1991</u>
Maintenance costs as a % of turnover .....	3.3	4.7
Maintenance costs as a % of capital value .....	2.9	4.1
Costs for maintenance of buildings as a % of capital value of buildings .....	1.1	1.0
Costs for maintenance of production, transport and storage equipment as a % of capital value of production plant etc.....	3.9	5.9
Costs for maintenance of rolling stock as a % of capital value of rolling stock.....	6.9	16.8
Rate of stockturn, spare parts .....	0.9	1.6
Value of spare parts stock as a % of capital value .	0.4	0.8

34. MANUFACTURE OF PAPER, PRINTING, PUBLISHING

	<u>1981</u>	<u>1991</u>
Maintenance costs as a % of turnover .....	1.9	7.2
Maintenance costs as a % of capital value .....	2.2	7.0
Costs for maintenance of buildings as a % of capital value of buildings .....	1.2	4.5
Costs for maintenance of production, transport and storage equipment as a % of capital value of production plant etc. ....	2.8	8.1
Costs for maintenance of rolling stock as a % of capital value of rolling stock.....	5.9	5.3
Rate of stockturn, spare parts .....	1.0	1.5
Value of spare parts stock as a % of capital value .	0.5	1.7

35. CHEMICAL AND PETROLEUM INDUSTRIES

	<u>1981</u>	<u>1991</u>
Maintenance costs as a % of turnover .....	3.0	4.7
Maintenance costs as a % of capital value .....	6.0	4.1
Costs for maintenance of buildings as a % of capital value of buildings .....	2.6	1.3
Costs for maintenance of production, transport and storage equipment as a % of capital value of production plant etc. ....	8.1	5.2
Costs for maintenance of rolling stock as a % of capital value of rolling stock.....	21.1	2.8
Rate of stockturn, spare parts .....	0.8	1.2
Value of spare parts stock as a % of capital value .	2.0	1.5

36. NON-METALLIC MINERAL PRODUCTS

	<u>1981</u>	<u>1991</u>
Maintenance costs as a % of turnover .....	8.3	10.7
Maintenance costs as a % of capital value .....	4.2	4.8
Costs for maintenance of buildings as a % of capital value of buildings .....	1.5	0.8
Costs for maintenance of production, transport and storage equipment as a % of capital value of production plant etc. ....	5.9	6.3
Costs for maintenance of rolling stock as a % of capital value of rolling stock.....	9.3	9.4
Rate of stockturn, spare parts .....	0.7	0.8
Value of spare parts stock as a % of capital value .	1.3	1.3



38. MANUFACTURE OF FABRICATED METAL PRODUCTS

	<u>1981</u>	<u>1991</u>
Maintenance costs as a % of turnover .....	3.3	3.5
Maintenance costs as a % of capital value .....	3.3	9.3
Costs for maintenance of buildings as a % of capital value of buildings .....	2.3	4.4
Costs for maintenance of production, transport and storage equipment as a % of capital value of production plant etc. ....	2.9	12.6
Costs for maintenance of rolling stock as a % of capital value of rolling stock.....	6.6	9.0
Rate of stockturn, spare parts .....	1.3	3.2
Value of spare parts stock as a % of capital value .	0.4	1.3

# DDV ANALYSIS 1991

## THE COMPANY

1. Name of company: .....
2. Name of division/department/company: .....  
(Please state here the department/division or company to which the responses refer)
3. Name of person who has completed the questionnaire: .....  
Tel.: .. - .....
4. In which industrial sector does the company work?
 

<input type="checkbox"/> Manuf. of food, beverages, tobacco	<input type="checkbox"/> Manuf. wood products + furniture
<input type="checkbox"/> Manuf. paper, printing, publishing	<input type="checkbox"/> Chemical and petroleum industries
<input type="checkbox"/> Non-metallic mineral products	<input type="checkbox"/> Manuf. fabricated metal products
<input type="checkbox"/> Textiles, clothing, leather industry	<input type="checkbox"/> Construction
	<input type="checkbox"/> Manufacture of plastic products
5. Number of employees in 1991 (full-time) approx. .... persons
6. Turnover, 1991 excl. any duty and VAT: approx. .... DKK  
of which exports constituted: approx. .... DKK
7. Capital value in 1991 (replacement value): approx. .... DKK  
(If the replacement value differs from the insurance value give the replacement value)
8. Distribution of capital value estimated in %:
 

A. Buildings incl. building installations:	approx. .... %
B. Storage, production + transport equipm:	approx. .... %
C. Rolling stock (cars, trucks, etc.):	approx. .... %
D. Other, describe: _____:	approx. .... %
Total capital value:	100 %

## MAINTENANCE COSTS

9. Maintenance costs in 1991: ..... DKK  
(Write here total costs for payroll, spare parts, materials, external services, administration, etc. in connection with maintenance of buildings, production plant, rolling stock and other)
10. Distribution of maintenance costs 1:
 

A. Buildings incl. building installations:	approx. .... %
Number of m <sup>2</sup> buildings: approx. .... m <sup>2</sup>	
B. Storage, production + transport equipm:	approx. .... %
Age (average): approx. .... years	
C. Rolling stock (cars, trucks, etc.):	approx. .... %
Age (average): approx. .... years	
D. Other, describe: _____	approx. .... %
_____	
Total maintenance costs	100 %

11. Distribution of maintenance costs 2:
- |                                      |                |       |
|--------------------------------------|----------------|-------|
| A. Pay to own maintenance employees: | approx. .... % |       |
| B. Spare parts and materials:        | approx. .... % |       |
| C. External services:                | approx. .... % |       |
| D. Administration etc.:              | approx. .... % |       |
| Total maintenance costs              |                | 100 % |
12. Distribution of maintenance costs 3:
- |  |                |       |
|--|----------------|-------|
| A. Unforeseen repairs:                     | approx. .... % |       |
| B. Planned repairs:                        | approx. .... % |       |
| C. Preventive maintenance:                 | approx. .... % |       |
| incl. industrial cleaning: approx. _____ % |                |       |
| D. Other (e.g. new plant), describe: _____ | approx. .... % |       |
| Total maintenance costs                    |                | 100 % |
13. Estimated distribution of costs for external services in connection with maintenance of:
- |  |                |       |
|--|----------------|-------|
| A. Buildings incl. building installations: | approx. .... % |       |
| B. Storage, production + transport equipm: | approx. .... % |       |
| C. Rolling stock (cars, trucks, etc.) :    | approx. .... % |       |
| D. Other, describe: _____                  | approx. .... % |       |
| Total external services                    |                | 100 % |
14. Value of spare parts stock for maintenance approx. .... DKK

## KEY FIGURES

15. What key figures are used to measure the result of the maintenance work carried out? If you use key figures in your company, please write the key figure for 1991 in the right-hand column.

### COSTS?

- Maintenance costs/capital value approx. .... %
- Maintenance costs/turnover approx. .... %
- Costs of production losses (scrapping due to poor quality, production delays, extraordinary distribution costs etc.) due to unforeseen production stoppages approx. .... DKK/year
- Rate of stockturn, spare parts approx. ....
- Other, describe: ..... approx. ....

### AVAILABILITY?

- Downtime due to unforeseen stoppages approx. .... h/year
- Downtime for planned maintenance approx. .... h/year
- Availability of primary production plant approx. .... %
- Other, describe: ..... approx. ....

### SERVICE LEVEL?

- Number of complaints about maintenance work approx. .... No./year
- Average interval in hours from fault report to fault has been made good/plant operating approx. .... hours
- Other, describe: ..... approx. ....

### OTHER KEY FIGURES (e.g. concerning safety)

Describe: .....





## PLANNING AND CONTROL OF MAINTENANCE

25. Which of the following parameters are used in the planning of maintenance?
- Supplier directions
  - Official requirements
  - Other, describe: .....
  - Condition analyses
  - Downtime and cause of fault analyses
26. Which methods (write 1:EDP, 2:manual, 3:none) are used for registration and control of:
- A. Basic plant data (machinery data, drawings, instructions, etc.)
  - B. Preventive maintenance
  - C. Work orders
  - D. Maintenance costs
  - E. Spare part store
27. How detailed (write 1: individual machinery/buildings, 2: groups of machinery/buildings or 3: departments) is the company's registration of:
- A. Events (work performed, stoppages, faults, etc.)
  - B. Pay to own maintenance employees
  - C. Spare parts and materials
  - D. External services

## COMMENTS

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**EUREKA**

**European Benchmark Study on Maintenance**

**EBSOM - EU 724**

**Chapter 2**



# **MAINTENANCE AND AVAILABILITY IN NORWEGIAN INDUSTRY**

Per Schjøberg and Ståle Hunstad

of

SINTEF (The Foundation for Scientific and Industrial Research at the  
Norwegian Institute of Technology)

NFV (The Norwegian Society of Maintenance Engineers)

# MAINTENANCE AND AVAILABILITY IN NORWEGIAN INDUSTRY

## 1 INTRODUCTION

This presentation briefly summarises the results of an investigation into maintenance and availability in Norwegian industry. The project was initiated by the Norwegian Society of Maintenance Engineers (NFV), and has been carried out by NTH/SINTEF (the Norwegian Institute of Technology and the Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology).

The project was done between May - December 1991.

### 1.1 Objective

The objective of the project was to map the status of maintenance and availability in Norwegian industry. This has been used as a basis for preparing a plan of action to create efficient operation and maintenance.

### 1.2 Main issues

The collection of data was based on a questionnaire and concentrated on the following main issues:

- the company
- the maintenance department
- maintenance activities
- information systems in the maintenance work
- maintenance costs
- down time and stoppages
- maintenance during planning
- safety
- future maintenance

The information that has been collected has been made anonymous at the report stage.

### 1.3 Framework of the investigation

The investigation is mainly directed at onshore industry, especially manufacturing and processing companies. Operators on the Norwegian continental shelf were also surveyed in the investigation.

The sectors that were selected are:

- oil industry
- engineering industry
- iron, steel and other metal industries

- mining and quarrying
- food industry
- printing, publishing and allied industries
- woodworking industry
- wood processing
- chemical industry
- textile manufacturing
- energy production
- cement and concrete industry
- plastics industry
- packaging

#### 1.4 Response to the investigation

The questionnaire was sent to 725 relevant companies. 194 completed forms were returned, which gives a reply percentage of about 27. In general, all the questions on the questionnaires received were answered satisfactorily.

## 2 RESULTS

This section gives the results of the investigation. The next section uses these results to present an average Norwegian company in terms of maintenance issues.

### 2.1 The company

Companies in the food-, engineering- and chemical industries make up around 60% of the total number in the investigation (see Figure 1).

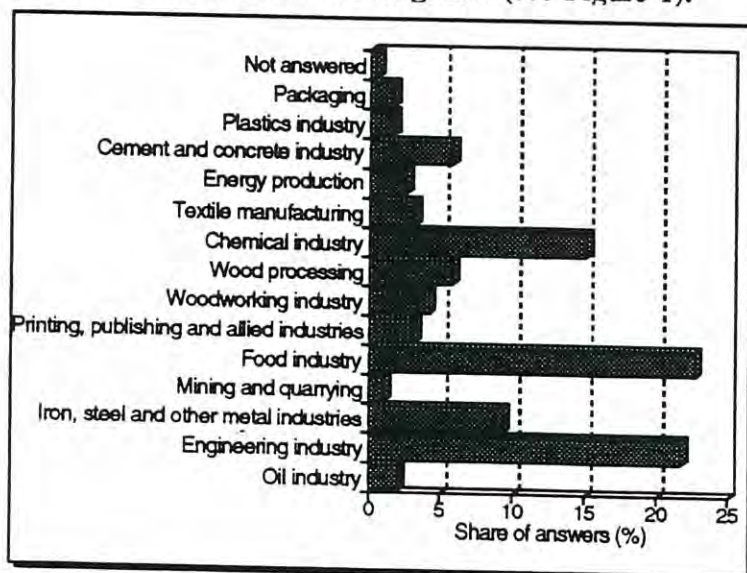


Figure 1 Distribution of answers received by sector.