The 1:40 scale models have shown reasonable results with the echogram interpretations, initial time delay gap, and temporal energy ratios. Even extremely crudely built models can yield a significant amount of information especially for unfiltered noise studies.

Table I. Comparison of wide band noise signal at center balcony position.

Room	Initial Time Delay	Rise Time 5 dB	Rise Time 3 dB	dB Decay 160 ms
Prototype	0.012s	0.0186s	0.0514s	4.6 dB
1:10 model	0.011	0.0193	0.0492	6.3
1:40 model	0.011	0.0183	0.0524	5.0
1:100 model	0.007	0.0225	0.0565	7.5

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Computer Program for predicting the Energy Consumption and Operating Costs of Boiler Plants

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KEYWORDS

Boiler Plant, Energy Consumption, Space Heating

ABSTRACT

Designing new boiler plants or renovating existing boiler plants for heating buildings will generally mean that a number of alternatives will have to be evaluated. Careful choosing can result in substantial reductions in costs and/or energy consumption. Since this evaluation procedure is extremely labour-intensive, only a few alternatives are usually considered. The aim was to develop a boiler selection program for analysing rapidly and accurately the energy consumption and operating costs of boiler plants.

The principle of the boiler selection program is based on the calculation of the hourly useful output and the energy consumption of the boiler plant. To do this a theoretical model was included in the boiler selection program, containing the ratios between full-load efficiency, standstill-loss and utilization efficiency. Also included in the boiler selection model is an economic evaluation feature. The program simulates the behaviour of the boiler plant based on output data covering not only the boiler plant to be simulated and economic factor, but also the hourly heat demand and outside temperatures.

The boiler selection program developed has been validated by tests in an existing boiler plant. The discrepancies in energy consumption between the actual measurements and the simulation calculations were between 0.1 and 5.7%. It can be concluded from this that the correlation between reality and simulation is good.

Programme d'Ordinateur pour la prédiction de la Consommation d' Energie et des Frais d'Exploitation des Chaufferies

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MOTS CLEFS

Chaufferies, Consommation d'énergie, Chauffage des locaux

SOMMAIRE

La conception de nouvelles chaufferies ou la rénovation de chaufferies existantes destinées au chauffage de bâtiments implique désormais une évaluation de diverses solutions. Un choix judicieux peut se traduire par une réduction substantielle des coûts et/ou de la consommation d'énergie. Comme cette évaluation exige un travail considérable, elle se limite la plupart du temps à quelques solutions. Le but était de développer un programme de sélection de chaudières permettant d'analyser de manière rapide et précise la consammation d'energie et les coûts des chaufferies.

Le principe du programme de sélection de chaudières tepose sur le calcul du rendement et de la consommation horaires de la chaufferie. A cet effet, le programme de sélection de chaudières englobe un modèle théorique prenant en considération la relation entre le rendement à pleine capacité, les pertes à l'arrêt et le rendement d'exploitation. Le modèle de sélection de chaudières comprend également une évaluation économique.
Le programme simule le comportement de la chaufferie à partir des données d'entreé qui, outre les données relatives à la chaufferie à simuler et les données économiques, comprennent la demande de chaleur horaire et la température extérieure.

Le programme de sélection de chaudières ainsi développé est validé par des mesures effectuées sur l'installation existante. Les écarts de consommation d'énergie entre les mesures et les calculs produits par la simulation se situent entre 0,1 et 5,7%.
On peut donc en conclure que la simulation est le reflet exact de la réalité.

1. INTRODUCTION

The design of new boilerplants for space heating and the partial replacment of existing boilerplants, involves a thorough evaluation of a number of alternatives. A good choice may very well lead to a substantial reduction in costs and/or energyconsumption. The evalution procedure, being very time-consuming, is therefore often limited to a few alternative boilerplants. The TNO Boilerselection-program presented here offers an accurate and fast method for the analysis of energyconsumption and costs of boilerplants.

2. THEORY

The basic principle of the Boilerselection-program is the hourly calculation of utilization efficiency and fuelconsumption of the boilerplant. The use of the utilization efficiency η_u instead of the boiler full-load efficiency η_b for energyconsumption calculations, has been introduced by Dittrich, who related the two as follows:

$$\eta_u = \eta_b / [1 + (1/B - 1) * q_s]$$

where B is the degree of utilization and q_s is the boiler's standstill-loss. The hourly fuelconsumption ϕ_f may then be calculated using:

$$\phi_f = (P_{max} * B * 3600)/(H_b * \eta_u)$$

where P_{max} is the maximum boilerpower (kW) and H_b is the gross calorific value of the fuel (kJ/m³).

In reality q_s, η_b and B are not constant. The standstill-loss of a boiler depends on boilerconstruction, watertemperature, flue-draught, cycle frequency and length of "OFF" period during cycling operation. The boiler full-load efficiency depends on boilerconstruction, watertemperature and burner-control. The degree of utilization depends on total installed power and building heatdemand. In the Boilerselection-program all these and other relevant variables are related in a theoretical model. Beside the analysis of boilerplant-operation, also an economical evaluation forms part of the Boilerselection-program, using the so-called present worth value (P.W.V.) method.

```
PLANT + OPERATION DATA    (IRRELEVANT = 0)

NUMBER OF BOILERS:

WATERCIRCUIT:
     PRIMARY   : WATERVALUE (KG):            H.T. COEFF. (W/M 2.K):          AREA (M 2):
     SECONDARY : WATERVALUE (KG):            ROOMTEMP. (C)         :

BUTTERFLY VALVES:             (YES OR NO)

BOILERHOUSE TEMPERATURE (C):                 BOILERTHERMOSTAT DEVIATION (C):

CONTROL (AVER.) BOILERWATERTEMPERATURE
     CONSTANT               : TBDES (C)
     WEATH.DEP. NORM./DAY: TBDES (C)        THL (C):      TAMB DES (C):      TB MIN (C):
                MIN. WATERTEMPERATURE LIMIT     (C):
                WK.END/NIGHT: TBDES (C):    THL (C):      TAMB DES (C):      TB MIN (C):
                NIGHT PERIOD, TIME BEGINNING    (H):      END (H)     :      (WHOLE HOURS)
     VARIABEL               : TBDES (C):    THL (C):      TAMB DES (C):

FUELCODE        :             (1 = NAT. GAS, 2 = OIL 2, 3 = OIL 6)
BOILERSEQUENCING:             (1 = CASCADE, 2 = RESERVE, 3 = PARALLEL)

TO CONTINUE, PRESS ENTER


DATA PER BOILER (IRRELEVANT = 0)

BOILER NO.:
WATER VALUE (KG):
H.T. COEFF. (W/M 2.K):
BOILER AREA (M 2):
BURNER: PFAN (KW):                PURGEPERIOD (S):
IGNITION CODE:     (1 = PILOT, 2 = ELECTRICAL, 3 = ELECTR. + IGN. BURNER)
        VOL. FLOW OF STANDING PILOT (M 3/3):
BURNERCONTROL CODE                (SELECT ONE OF THREE)
        ON/OFF    :    (1)
        HIGH/LOW  :    (2)      PLOW    (%):        TH/L (C):
        MODULATING:    (3)      PTHRESH (%):
BOILER LOAD                    MAXIMUM (KW):        NOMINAL (KW):
BOILER TYPE, STANDSTILL - LOSS
        STANDARD     :  A0:      A1:      A2:      A3:      (FST)
        ECONOMIZER   :  A0:      A1:      A2:      A3:      (FECO) PFAN(KW):
        FLUEGAS VALVE:  A0:      A1:      A2:      A3:      (FFGU)
        DIR.EFFICIENCY  C0:      C1:      C2:      C3:      (FCT) (MIN.IPUT CO)
        DIR.EFF. LOW/THR.C0:     C1:      C2:      C3:      (FCT) (MIN. INPUT CO)
        DIR.EFF. MODUL. B0:      B1:      B2:      B3:      (F) (REL. LOAD)
TO CONTINUE, PRESS ENTER


COST/BENEFIT DATA:        PLANT CONSIDERED          REFERENCE-PLANT (IRREL.= 0)

FUEL PRICE FIRST YEAR          (FL/M 3 OR KG):
INVESTMENT                              (HFL):                 :
NOMINAL INTEREST                          (-):
PERIOD OF REDEMPTION                      (Y):
PERCENTUEL RISE OF ENERGY PRICE           (-):
MAINTENANCE AND REPAIR COSTS (PER YEAR)  (FL):                 :
INFLATION PERCENTAGE                      (-):
TECHNICAL LIFETIME                        (Y):
TAX REDUCTION FACTOR                      (-):
ENERGY CONSUMPTION               (M 3 OR KG)                   :
TO CONTINUE, PRESS ENTER
```

Fig. 1. Input-sheets of Boilerselection-program

3. COMPUTERPROGRAM

3.1 Input

In theory a large number of different boilerplantconcepts can be designed. Which boilerplants can be analysed by the Boilerselection-program may be derived from the input-sheets, presented in fig. 1. By adressing input data only to those variables that are relevant for the boilerplant considered, this plant will be "profiled" in the Boilerselection-program. Beside the plant-data, also the hourly results of a (dynamic) building heatload calculation (based for instance on a reference year for weatherconditions) must be available for input.

3.2 Calculation procedure

The calculation procedure of the Boilerselection-program is illustrated by the simplified flow sheet, presented in fig. 2. This calculation is to be executed per hour during the period for which the hourly heatdemand is known. At the end of this period the economical evaluation starts, using the calculated energyconsumption as an input.

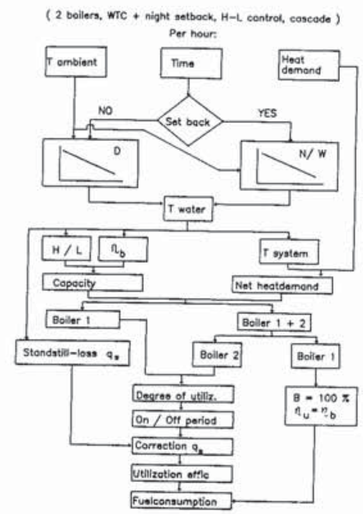

Fig. 2 Illustration of calculation procedure

3.3 Output

After termination of the calculations, the Boilerselection-program produces data on the following subjects:

Per hour (e.g.): building heatdemand (= input), watertemperature (per boiler), degree of utilization (per boiler), burner operation (per boiler), fuelconsumption (of the plant), utilization efficiency (of the plant).

On the year's basis (e.g.): total building heatdemand, boilerplant energyconsumption, utilization efficiency, P.W.V. of running costs, pay-back period of investment.

4. VERIFICATION OF THE COMPUTERPROGRAM

The Boilerselection-program has been verified by measurements on an existing boilerplant (475 kW atmospheric boiler), for three different operating conditions. These conditions for the measurements are:

A : constant watertemperature (70 °C) and On-Off burner control

B : weatherdependent watertemperature and On-Off burner control

C : weatherdependent watertemperature and High-Low burner control.

Both boilerplant behaviour and fuelconsumption have been verified, but also investigations into the boilerplant's properties have been carried out.

4.1 Boilerplant behaviour

How the Boilerselection-program simulates the actual boilerplant behaviour is illustrated in fig. 3, where various variables are compared for one day of measurement C. The agreement between measurement and simulation is good.

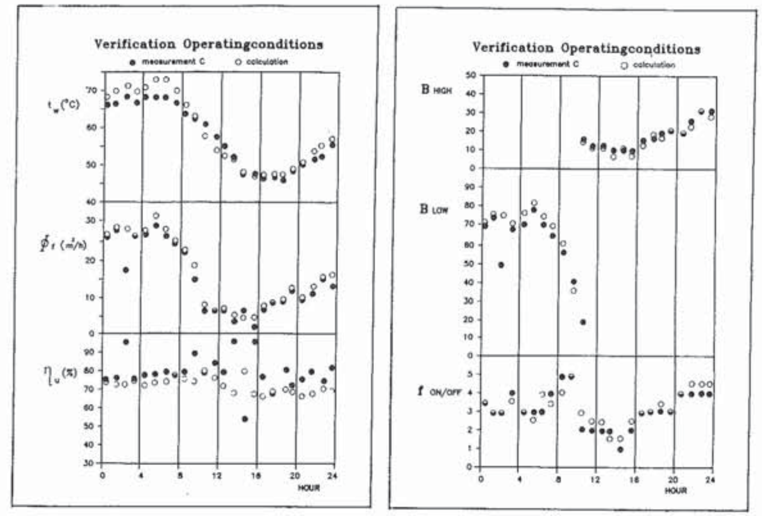

Fig. 3. Comparsion between measured and calculated data

4.2 Fuel consumption

Table 1 shows a comparison between the measured and the calculated boilerplant fuelconsumption. Here too the agreement between the two is very good.

Table 1. Results of verification measurements (M) and calculations (C)

			A	B	C
M	Fuelconsump. Utilization eff.	m^3_n %	1392 72.6	743 71.7	1022 76.9
C	Fuelconsump. Utilization eff.	m^3_n %	1393 72.5	748 71.2	1079 72.8
	Deviation (C-M)	%	+ 0.1	+ 0.7	+ 5.7

5. APPLICATION

The application of the Boilerselection-program is illustrated by the analysis of a number of boilerplants with respect to fuelconsumption. For the calculations a heatdemand and ambient temperature pattern was used, that had been derived from the verification measurements. Fig. 4, showing the results of the calculations, also illustrates the variety of boilerplants that can be analysed with the Boilerselection-program.

Fig. 4 Boilerselection-program, results of analysis of various boilerplants. (V = cascade, O = reverse seq.; A = on-off, H = high-low, M = modulating; C = convent.eff, H = high eff.; W = weatherdep., C = constant; SK = butterfly v., "150" = 50% overcapacity).

6. CONCLUSIONS

1. The Boilerselection-program is a valuable tool for the design and evaluation of new boilerplants for space heating in buildings.
2. The Boilerselection-program has been verified with measurement in an existing boilerplant; the agreement between reality and simulation is good.

ACCURACY DATA OF A STRUCTURE DESIGNED ACCORDING TO THE LIMIT STATE DESIGN METHOD

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KEYWORDS

limit state design, setting out, measuring-in, accuracy data (collection, calculation, presentation), positional and dimensional deviations, deformations of load bearing parts

ABSTRACT

In Sweden new regulations - applying the method of limit state design - have been introduced on a voluntary basis and will become compulsory within a few years. On a building site SIB investigated the geometrical consequences of these regulations in practice. This field study, which is the first of its kind, consists of two parts:

* Determination of deviations due to e g setting out or shuttering
* Determination of deformations of the structure as a possible result of the regulations

In both parts modern surveying techniques were applied for the collecting of a large number of accuracy data. One of them was the method of "Free station points".

The local A, B and C coordinate system on the site was chosen as the reference object for the measuring-in and the calculation of accuracy data for different items. The coordinate points were marked by elevated target points in the primary net work around the site.

The advantage of using coordinate systems as reference in this kind of research is, that from observed positional deviations other deviations, e g from verticality, thickness, eccentricity, slope, straightness of flatness, can easily be derived by the computer.

After storage of the data in the computer, statistical parametres were calculated. The results were graphically presented in different ways: histograms, circle diagrams or contour lines giving a direct view over the degree of the flatness of e g a floor slab. The study does thus also give information about alternative uses for the computer in collecting accuracy data.

It is expected that the application of the new regulations will require more attention to accuracy than at present. The paper therefore contains examples of some interesting accuracies and comments e g on how these accuracies can easily be improved. Improvements do not necessarily require the use of the latest innovations in measuring - or production technique, more important simply is a better communication between office and site.