

Tomasz Hajduk, Zenon Bonca

Usage of a Computer Based Training Program for a Refrigerating Plant, a New Tool for Marine Engineers Training

Key words: refrigeration engineering, marine refrigerating plant operation,
didactic tools, simulators, cbt software

*The paper presents the didactic and training capabilities of computer-based training software – **Refrigerating Plant**. The objective of this paper is to describe the basic features of the above-mentioned program such as: its structure, its contents, method of trainee assessment and how to navigate through it. The benefits of using such software in the field of marine engineering education and training have also been mentioned.*

Wykorzystanie programu komputerowego typu cbt – chłodnia powiantowa jako nowoczesnego narzędzia dydaktycznego w kształceniu mechaników okrętowych

Słowa kluczowe: technika chłodnicza, okrętowe urządzenia chłodnicze, eksploatacja,
narzędzia dydaktyczne, symulatory, programy edukacyjne typu cbt

*Przedstawiono możliwości szkoleniowe dydaktycznego programu komputerowego typu cbt – **chłodnia powiantowa**. Omówiono jego strukturę i zawartość merytoryczną. Podano sposób oceny osoby nauczanej wykorzystującej ten program. Wskazano korzyści płynące z zastosowania programów typu cbt w procesie kształcenia mechaników okrętowych.*

Introduction

Worldwide, dynamic growth has recently been observed in some industry branches. New produced devices are more reliable but on the other hand, they are more complicated in their constructions. Some of them are manufactured by means of using new important discoveries of science and technology. Naval technology has not been passed over by this development, particularly on a large scale of ship design and building, building of ship's machinery, automation of processes realized on ships, methods of ship management and operation, too.

Considering the ship's value, the safety of the crew and environmental protection aspects, both the dangerous nature and high value of the cargo shipment by means of some modern ships (large container ships, tankers, car, gas and chemical cargo carriers), running these ships is a great responsibility of the crew. Hence, the operation of a modern ship obliges each crew member to get higher qualifications and improve their knowledge periodically. It is also commonly known that high concentration, a reasonable way of thinking, a great sense of responsibility and resistance to stress are recommended for marine engineers. Thus, the method for training the above-described personnel should be executed at the appropriate level of education [3, 4, 5].

Bearing these considerations in mind, the problem of how to educate a present marine engineer (who should absorb much more knowledge at the same period of education more effectively) still exists. One proposed remedy is to lengthen the period of education, but the result of its application would be rather expensive. So, there is a need of looking for new training tools, which are much more effective in the field of maritime engineering education. Among other equipment and methods, the desirable result of getting highly educated, specialised marine engineers can also be achieved by means of simulators [3, 4, 5].

1. The role of simulators for present marine engineers' training

Today, simulators have become increasingly important for training marine engineers. The benefits of utilising them are considerable and manifold, as well as commonly appreciated. Among other elements, the measurable benefits coming from this method of education include [1, 5, 8]:

- lower price of the simulator than the real object,
- the same level of repeatability of the educational process,
- shortened time of training,
- the examination of a trainee is possible in extreme operational situations (e.g. emergency ones) without health hazard,

- the opportunity to carry out chosen operations at almost any time,
- minimising cost and eventual material losses in comparison with education by means of using the real object,
- easy extensibility,
- possibility of trainee skills assessment by using competence test programs,
- high flexibility due to a modular architecture.

It is also worth adding that the simulator which can meet all the above mentioned benefits does not exist. The benefits of using a given simulator depend strongly on the objective it was designed for and the level of training it was intended for (watch-keeping or management level).

2. Classification of simulators designed for marine engineers' training

At present, there are different types of simulators intended for marine engineers' training on the world scene, however the still lacking simulator classification is a serious problem in discussing the issue of simulator application [6].

The author of papers [6, 7] proposes the division of simulators into four classes. A special table was presented, showing the relation between learning skills and simulator type dependent on the marine engineer's rank in this paper. The author assesses particular simulators in a descriptive way by using such words as: 'very appropriate', 'appropriate', 'sometimes appropriate' and lack of word means 'inappropriate'. The classification comprises the following types of simulators:

- **B (Basic) Class** of simulators – includes Computer Based Training (CBT) software and Basic Machinery simulators such as: auxiliary boiler, refrigerating plant, steering gear, etc. This family of simulators has a form of computer software to be run on a single, multimedia PC. The user interface is based on a simple computer animation and simulated technical sounds. The absence of any special hardware consoles and the moderate cost are also typical. The Unitest CBT package which includes several B Class simulators can be an example of this simulator type;
- **P (Personal) Class** of simulators – includes mainly Hybrid and Part Task simulators and they are designed for a single person training: both in a stand-alone mode and a supervised one. The user interface is like in B class simulators, but a limited number of hardware consoles (usually

of a desktop type) is sometimes offered. A Virtual Engine Room is an example of this class;

- **F (Full) Class** of simulators – includes highly realistic and very expensive Full Mission simulators. The set of hardware consoles equipped with gauges, switches, lamps and push-buttons and many simulated sounds are obligatory for this class. The high investment and operation cost are their main disadvantage but on the other hand the possibility of team training (e.g. manoeuvring) is a very important advantage of that simulator type). The Engine Room Simulator (ER-SIM) is an example of this group;
- **S (Special) Class** of simulators – simulators which are rather more complicated and sophisticated in comparison with B Class of simulators. They have different tasks and rarely offer any theoretical background or operational instructions. Examples of this family are: a diagnostic simulator – Turbo Diesel and a liquefied petroleum gas-handling simulator [6].

The application of different simulator types designed with the specific education task in mind seems to be a better and more effective solution than trying to build more and more complex and sophisticated ones able to fulfil almost any educational task [6].

The Faculty of Marine Engineering of the Gdynia Maritime University has got all the above mentioned kinds of simulators and uses them during the student (sim-lab exercises) and marine engineers' training (Studium Doskonalenia Kadr Oficerskich labs).

3. Description of the CBT educational programs

As it was mentioned in the previous chapter of this paper, CBT programs belong to the B class of simulators. Such software usually covers one engine room system or one machinery, but this coverage is very thorough, detailed and includes the following issues [1, 6, 8]:

- the principle of operation;
- three-dimensional (3D) graphical visualization of machinery elements for better understanding their operational principles;
- description of start, stop and other characteristic procedures of a given machinery or system;
- the mini-simulator of the system being the simulator main subject;
- test of competency as an assessment.

Bearing in mind, some considerable research and development activities which have been carried out over the last five or so years in the field of CBT at the GMU by the authors of paper [1], it is worth emphasising that these programs' basic objectives, tasks and features should be to:

- familiarise learners with individual auxiliary shipboard systems or equipment;
- develop operational skills;
- train and master emergency procedures;
- combine simulations with multimedia techniques such as animation, diagrams, pictures, sound, etc.;
- develop and improve the English language skills of the ship's personnel;
- intensify the trainee's activities during the education process;
- make the learning process shorter with a simultaneous increase in quality;
- make the assessment process of trainees much more comprehensive and objective [1].

The above-mentioned considerations have led to the hypothesis that such programs could lead to increase the didactic efficiency in a wide range of engineering education aspects.

4. Structure of the educational CBT program – Refrigerating Plant

The training program **Refrigerating Plant** – training simulator is designed for learning the essential principles of a one-stage refrigeration system operation. In its present form, it is the second, upgraded version of the simulator from 1997 [2]. This version completely meets all up-to-date requirements for the creation of such simulators.

Generally, this version has been enriched with useful pieces of information on the fundamentals of refrigeration theory. It has also been improved by practical issues about the operation of a simple refrigeration unit. An assessment test is also attached to this program.

The structure of this simulator consists of the following modules, which are visible at the main menu window:

- Basic parameters of the thermodynamic state,
- Thermodynamics of vapours – fundamentals,
- Vapour – compression refrigeration cycle,
- Equipment,
- Main automatic control and safety devices,

- Operating procedures,
- Simulator,
- Assessment.

All modules listed above are integral parts of the program. It means that a trainee can exercise in their own established order, but the recommended mode of training is the hierarchic one. That is the way of learning where the trainee analyses modules in order from the first to the last. Below, a short characteristic of each module has been presented.

4.1. Basic parameters of the thermodynamic state

This module contains essential theoretical information necessary to achieve a better understanding and proper analysing processes of a simple refrigerating vapour-compression cycle. In this module, there are basic issues particularly concerned with heat transfer and with the thermodynamic state basic parameters such as temperature, pressure, density, specific volume, enthalpy, entropy (units, ways of a given parameter measurement, etc.). Knowing what the above mentioned parameters are helps to use the refrigerant Mollier's chart adequately. Some pieces of information were also supported by exemplary calculations.

4.2. Thermodynamics of vapours – fundamentals

This module consists of essential theoretical information about the fundamentals of vapour thermodynamics. Among other information, the isobaric process of fluid evaporation has been presented in a graphic way. The degree of dryness, thorough analysis about thermodynamic diagrams such as T-s, p-h (Fig. 1), and an exemplary scan of real refrigerant (R 134a) Mollier's chart were presented, too.

4.3. Vapour – compression refrigeration cycle

Some basic information of refrigerating engineering is presented in this module. The definition of cooling, methods of temperature lowering, the theoretical refrigerating cycle of Carnot, the comparative refrigerating cycles of Linde (by wet and dry compression) have also been described. A detailed description of the operation principle of a one-stage vapour-compression refrigerating cycle equipped with the heat exchanger has been given as well. The formulas and definitions of characteristic parameters of the simulated cycle and a few exemplary calculations have been presented in the final part of this module.

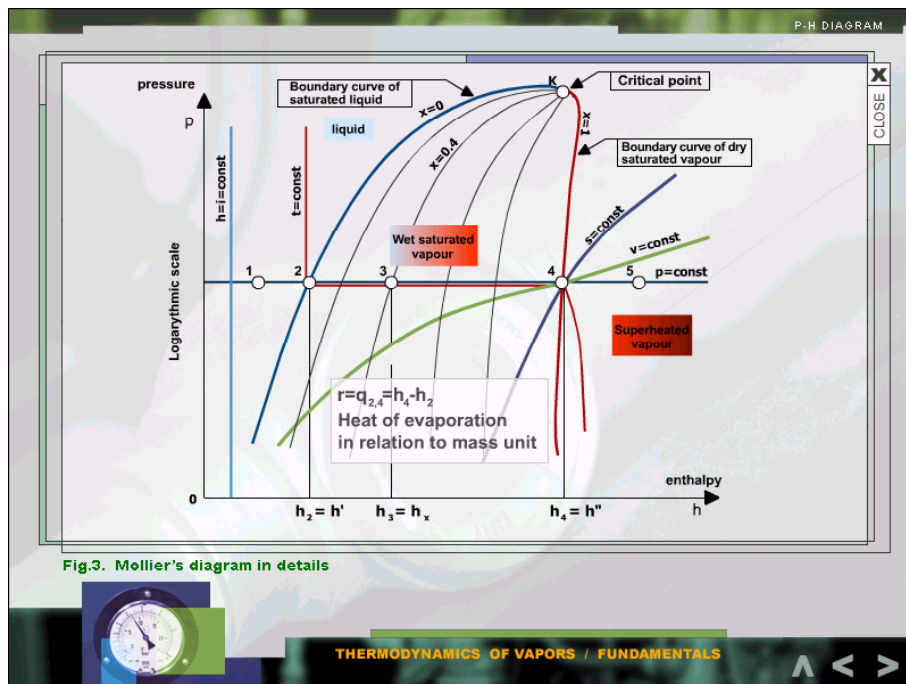


Fig. 1. A screen showing Mollier's diagram in details

Rys. 1. Ekran przedstawiający przemiany termodynamiczne na wykresie Molliera

4.4. Equipment

This part of simulator contains theoretical information about the working principles of basic elements of the refrigerating plant and practical issues how to operate them in a proper way. Described elements comprise: a compressor, a condenser, a thermostatic expansion valve, an evaporator, a heat exchanger, an oil separator, a dehydrator, a sight glass flow indicator, cut-off valves, thermometers and refrigerating gauges. Apart from the text, real pictures, sections, drawings in 3D format as well as animations of the above-mentioned elements (Fig. 2) have also been presented.

4.5. Main automatic control and safety devices

This part has information about sorts, structures and how to set the main automatic controls of the refrigerating plant. These issues are mainly based on well-known practice, linked directly with a given control element, for example how to adjust accordingly: low and high pressure control, differential pressure control, chamber thermostat (such as shown in Figure 3), constant pressure valve.

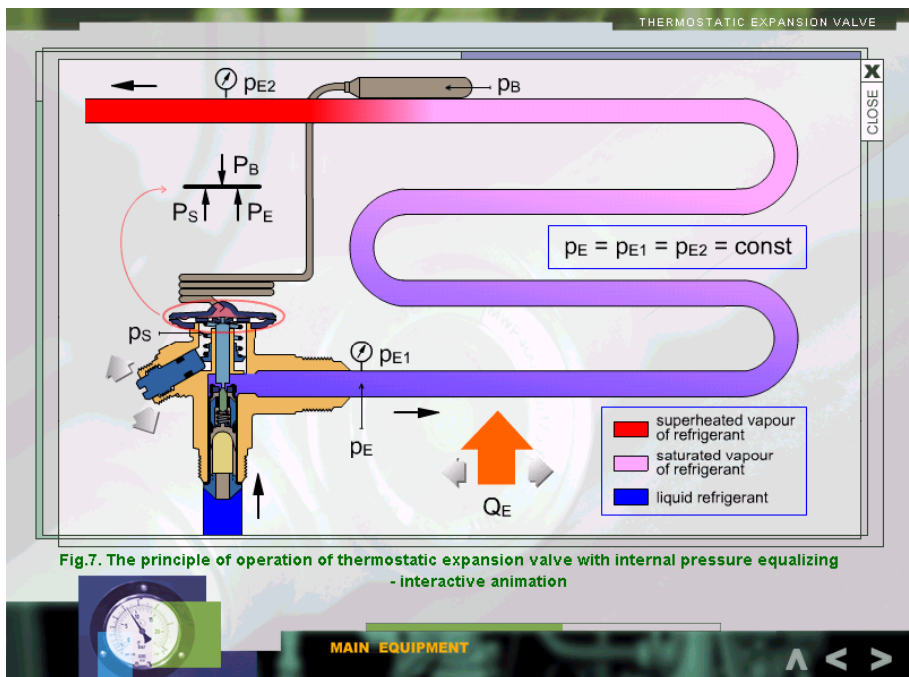


Fig. 2. A view of TEV operation principle - an interactive animation
 Rys. 2. Ekran obrazujący zasadę działania termostaticznego zaworu rozprężnego z wewnętrznym wyrównaniem ciśnienia – animacja interaktywna

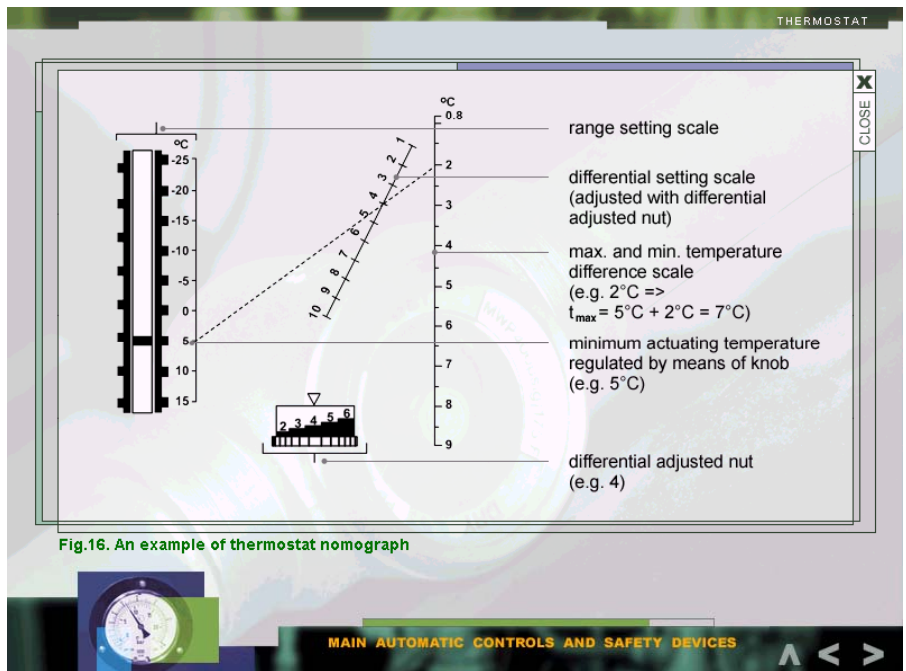


Fig. 3. An example of chamber thermostat setting – a nomograph
 Rys. 3. Ekran przedstawiający nomogram do nastawiania termostatu komorowego

4.6. Operating procedures

This module includes a detailed ‘step by step’ description of the preparation for operating procedures of the refrigeration plant. It is like an operation manual, which was divided in specially determined operating tasks, in the field of simulator nomenclature, sometimes called procedures. The following procedures of the plant operation were described as [9]:

a) concerned with the working of the refrigerating plant:

- starting,
- continuous running,
- stopping,
- cold chamber automatic defrosting,
- cold chamber manual defrosting;

b) concerned with automatic controls setting:

- low suction pressure setting,
- maximum compression pressure setting,
- differential pressure control setting,
- cold chamber temperature setting.

Apart from the operating capabilities listed above, this simulator has a possibility of training some simple operating inefficiencies such as faulty opening and closing of the main suction valve, decreasing in cooling intensity of the condenser, disabling one chamber, etc.

4.7. Simulator

The simulating program is based on a refrigerating plant equipped with two cold chambers, one-stage piston compressor, a heat exchanger and refrigerating medium R22. Cold chamber number 1 (in colloquial expression sometimes called ‘heavy’) serves to obtain minus temperatures ranging from -30°C to -15°C while the cold chamber number 2 is to achieve plus temperatures (in colloquial expression sometimes called ‘light’) from 0°C do $+15^{\circ}\text{C}$. The scheme of a simulated refrigerating system is presented in Figure 4.

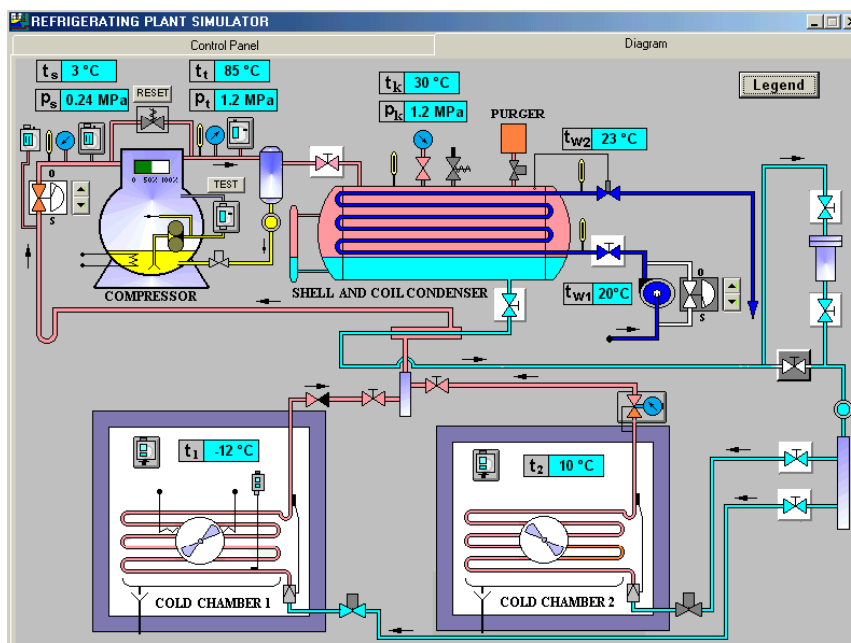


Fig. 4. A screen of simulated refrigerating plant installation

Rys. 4. Ekran przedstawiający schemat instalacji dwukomorowej chłodni prowiantowej

4.8. Assessment

This module includes a competence test, which is intended to estimate the level of knowledge gained by a trainee from the program. The idea of test looks as follows: a trainee should indicate only one answer (from three answers, see Fig. 5) to ten randomly selected (from tens) questions. In case of incorrect answering a trainee can peep at the correct answer placed in the bottom part of a given screen, but what is worth emphasising is that a trainee can answer one question only once. At the end of the test, a trainee is given a test mark, indicating the percentage of correct answers (each correct answer equals ten points) [1, 8].

Navigation through the program is very easy and seems to be an intuitive one. The mouse is only one navigation tool used to run all applications within the program. There are four accessible navigation keys such as: ‘^’ – leaving a given module and going to the upper level, ‘<’ – going back to the previous screen within a given module, ‘>’ – going forward to the next screen within a given module, ‘x’ – closing a given application and key ‘EXIT’, when pressed causes leaving the program and showing the training report presented in Figure 6. This report includes: trainee name, date when training was completed, total time of using, percentage of progress in modules using and test score. It can be printed or skipped.

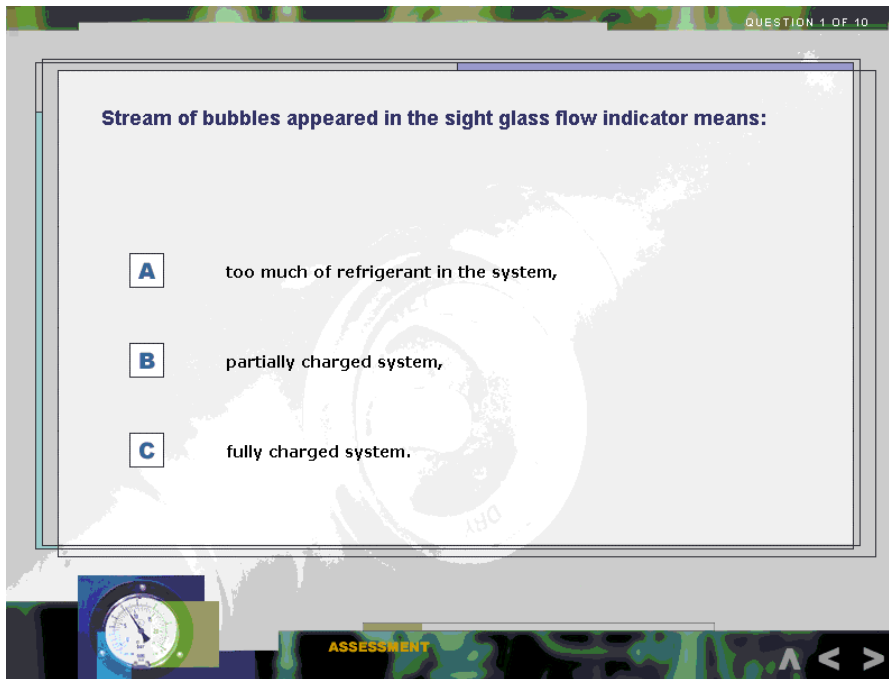


Fig. 5. An exemplary test question
 Rys. 5. Przykładowe okno dialogowe testu sprawdzającego

Training report
 CBT: Refrigeration System

Trainee name:	Cezary Sopol	Total time used:	25 minutes
Date completed:	18 September 2003		
Lesson	Completed	Test score	
1. Basic parameters of the thermodynamic state	64 %		
2. Thermodynamic of vapors / Fundamentals	100 %		
3. Vapour-compression refrigeration cycle	78 %		
4. Equipment	56 %		
5. Main automatic controls and safety devices	82 %		
6. Operating procedures	41 %		
7. Simulator	100 %		
8. Assessment	100 %	7 correct of 10	70 %
Total	78 %		

PRINT EXIT

Fig. 6. An example of training report printout
 Rys. 6. Przykład wydruku końcowego raportu dla osoby szkolonej

Conclusions

The educational cbt program – **Refrigerating Plant** is undoubtedly a modern didactic tool within marine engineering education. Its application in this field should lead a trainee to a better understanding of the principles of refrigerating plant operation of both the analysed system and analysed devices when compared with traditional methods of education.

As a modern training tool, simulators have broadened new horizons of education. However, the effective use of simulators is dependent upon the class of simulator (applied mathematical model, its real look and feel, its operational capabilities, etc) as well as being also dependent upon the instructor's preparation and trainee engagement in conducting the training process [1]. But it is worth adding that if they are used in an inadequate way, they could also result in some undesirable consequences for trainees [5].

In the case of cbt educational programs particularly, it is necessary to add that a trainee should never treat the simulator-lab exercises as a virtual game. Only a serious approach to these exercises will give the trainee benefit in their future occupation.

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dr hab. inż. Jerzy Listewnik, prof. WSM

Adresy Autorów

Tomasz Hajduk M.Sc. (Eng.)
Zenon Bonca Ph.D. (Eng.)
Gdynia Maritime University
The Faculty of Marine Engineering
Marine Power Plant Department
Morska Str. 83, 81-225 Gdynia, POLAND
e-mail: hajdi@am.gdynia.pl
phone (B) +48 (58) 6901 449
fax: +48 (58) 6901 399