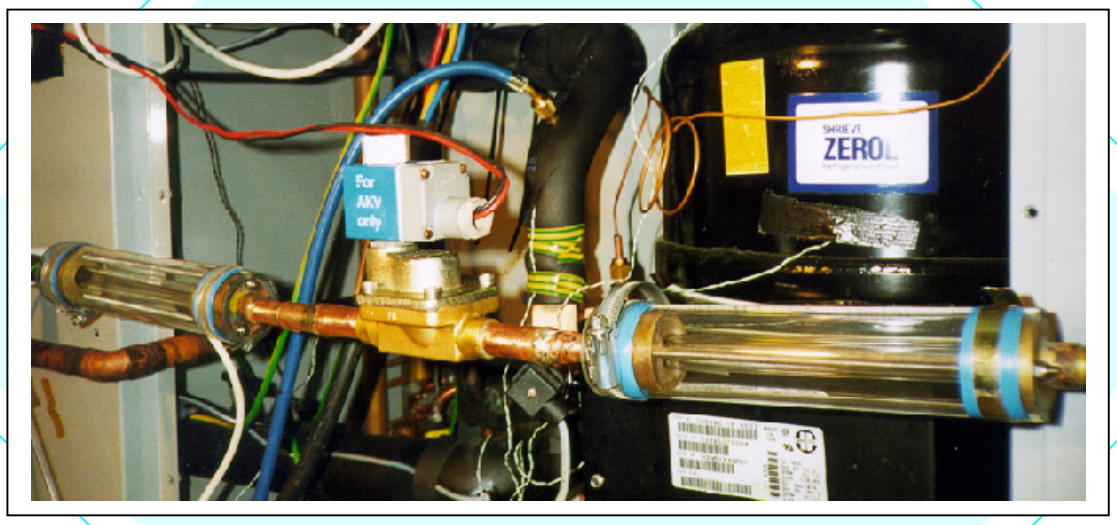
Technical Note TN 16/2000

ENERGY EFFICIENT CHILLER CONTROL

M A Roper



DETR
ENVIRONMENT
TRANSPORT
REGIONS

BSRIA

Technical Note TN 16/2000

ENERGY EFFICIENT CHILLER CONTROL

M A Roper

Old Bracknell Lane West,
Bracknell, Berkshire RG12 7AH
Tel: + 44 (0)1344 426511 Fax: + 44 (0)1344 487575
e-mail: bsria@bsria.co.uk www.bsria.co.uk

BSRIA

ISBN 0 86022 565 8 Printed by The Chameleon Press Ltd. ©BSRIA 78330 September 2000

ACKNOWLEDGEMENTS

BSRIA would like to thank the following sponsors for their contribution, which has led to the production of this Technical Note.

Department of the Environment, Transport and the Regions
EA Technology
Caradon Trend
IMI Air Conditioning Ltd.
Dean & Wood Ltd.
Danfoss Ltd.

Contributing from BSRIA were Mike Smith, Greg King, Mark Roper, Richard Newman, John Hope and Mark Pettitt.

This publication has been produced by BSRIA as part of a contract placed by the Department of the Environment, Transport and the Regions. The contract was let under the Partners in Innovation programme, which provides part funding of collaborative research. Any views expressed in it are not necessarily those of the Department.

The authors have sought to incorporate the views of the steering group, but final editorial control of this document rests with BSRIA.

EXECUTIVE SUMMARY

This document shows how by changing control strategy, conventional refrigeration based water chillers can operate more efficiently.

Most low cost air-cooled chillers supplied in recent years are fitted with thermostatic expansion valves (TEV) and head pressure control (HPC). This means that the machine is controlled in such a way that it operates as if the ambient temperature is high all year round. This is done to ensure the machine can produce a stated performance in terms of cooling capacity and to ensure reliable operation of the TEV.

As a result of HPC, more energy is consumed than necessary. In air conditioning duty, virtually all air-cooled chillers operate at part load for much of the year. When the weather is cooler, there is a potential for any refrigeration plant to operate with reduced energy use. HPC prevents these savings being realised.

The research work behind this publication involved the construction of a test facility to house a standard air-cooled chiller of 35kW cooling capacity. The facility allowed the chiller load and the ambient temperature to be controlled across a wide range of conditions. At no time were the chiller components operated outside the manufacturer's recommendations and after some two years of exhaustive tests, no problems have been experienced with the machine.

With the chiller operating under its "as supplied" control strategy, its performance was mapped for a range of ambient conditions representative of UK weather. Two sets of modifications were then made and the tests repeated. The first modification comprised simple manual control of the chiller condenser fan speed. This replaced the HPC. The second modification comprised the replacement of the supplied thermostatic expansion valve with more expensive components - an electronic expansion valve, sensors and associated control equipment. In addition, the condenser fan speed was under manual control.

The results showed that simple modifications could be made to the "as supplied" control strategy that would produce energy savings when operation was considered across a full year. Further savings could be made if the components that delivered HPC could be manufactured cost effectively to incorporate a slightly more sophisticated control strategy (proportional and integral action; currently they appear to be proportional only). Maximum savings would be achieved through the implementation of full condenser temperature control (CTC) using microprocessor control with appropriate control algorithms. Based on the single chiller tested, these savings could be realised without any reduction in cooling capacity.

Estimation was made of the potential CO_2 savings that could be realised if full CTC was applied. If only 10% of the stock of new machines purchased in the UK over the last ten years were modified, this would result in a saving of 10,000 tonnes of CO_2 per year, or approximately a 25% saving in energy use per machine. Implementing simpler

modifications would bring smaller, but still substantial, improvements in efficiency.

Specifiers of any refrigeration equipment should ensure the equipment they procure is capable of operating as efficiently as possible at all loads. HPC should be avoided and the small additional first cost of accepting machines fitted with electronic expansion valves will be easily repaid over the life of the machine in terms of reduced energy costs and reduced environmental impact.

The Enhanced Capital Allowances (ECA) scheme will provide increased tax relief for investments in energy-saving technologies. The scheme will build on existing provisions under which businesses obtain tax relief, in the form of capital allowances, for their investment in machinery and plant. This relief is normally given at a rate of 25% p.a., which spreads the benefit over a number of years. Enhanced capital allowances will enable businesses to take relief on the full cost in the first year. Refrigeration technologies that will be eligible include electronic expansion valves (EEVs) and "proactive devices" that can "control system devices such as electronic expansion valves to achieve maximum energy efficiency" – this would appear to include CTC devices that minimise the head pressure by controlling the condenser fan speed.

CONTENTS

TABLES

FIGURES

1 INTRODUCTION

This report describes a DETR and industry-funded research project carried out at BSRIA to investigate alternative control strategies for existing air-cooled chillers which incorporate thermostatic expansion valves (TEVs), and to consider ways of improving the chiller energy efficiency. Previous work by BSRIA has shown that heat rejection systems were operated in an inefficient manner for much of the year [1, 2].

For most air-cooled chillers, performance is stated (and sometimes certified) when operating at ambient conditions of approximately 35°C. When the ambient temperature falls, the systems could theoretically operate much more efficiently. However this does not occur in most cases, with the system being controlled to operate as if the ambient temperature is still high. Overall efficiency is sacrificed to allow a cheap and simple control regime. The aim of this project is to investigate just how large the potential efficiency gains are, and what alternative control methods might be used to realise them.