THE INSTITUTE OF PETROLEUM

GUIDELINES FOR THE SAFE AND OPTIMUM DESIGN OF HYDROCARBON PRESSURE RELIEF AND BLOWDOWN SYSTEMS

ISBN 0 85293 287 1

Published by The Institute of Petroleum

Further copies can be obtained from Portland Press Ltd. Commerce Way,
Whitehall Industrial Estate, Colchester CO2 8HP, UK. Tel: 44 (0) 1206 796 351
email: sales@portlandpress.com

CONTENTS

FOREWORD

These guidelines are intended for designers of relief and blowdown systems for offshore oil and gas installations and their associated onshore terminal facilities. They are addressed primarily to process engineers who will be familiar with the basic principles and calculation techniques involved. They incorporate aspects of the current practice of several operating companies (although these are not always in agreement) and refer to current published experience. They do not purport to be a code of practice or be prescriptive in any way and the designer should always refer first to current practice within his or her own organisation, information on which may not be in the public domain. There may be design practices or recommendations included which are different from previously designed facilities which the designer may be familiar with. It is the intention that such differences should in general result in improvements to safety, reliability, or cost. However, designers should always make such judgements for themselves, taking account of the experience of themselves and their organisations.

These guidelines have been written primarily for application offshore on the UK Continental Shelf (UKCS). Examples are given from the UKCS and Norway including a listing of incidents due to equipment failure or operator error. However, many of the recommendations may also apply to other parts of the world and although the main context of the work was on the safe design and operation of offshore facilities, the contents of these guidelines are considered to be applicable to both offshore and onshore plant worldwide.

The importance of relief and blowdown systems has led to extensive work being carried out by international bodies such as the American Petroleum Institute (API) and, under the aegis of the American Institute of Chemical Engineers (AIChE), the Design Institute for Emergency Relief Systems (DIERS). These bodies have produced codes of practice (typified by API RP 520 and 521) and it is not the aim of the present studies to produce an alternative code. The objective of these guidelines is to assess the methodologies (including those embodied in the codes) for their appropriateness and conservatism and to address practical aspects of design. Thus, the present document is aimed at supplementing the existing code documents and assessing some aspects of them.

It is hoped that this present document will be on the desks of designers and operators, together with (but not replacing) the international code documents, international standards and any documents describing practice within their own companies. Guidance is given on some of the more contentious issues/definitions which can give rise to misunderstanding in the design of relief and blowdown systems.

These guidelines emphasise the following salient points:

Design philosophy. It is vitally important to carefully think out the philosophy of design at the very beginning of the design process and to refine and develop this philosophy as the design proceeds. Many of the problems which have occurred in relief and blowdown systems result from a lack of strategic vision of the approach to be taken.

System changes. Most operating systems undergo, during the period they are used for production, changes of one form or another. These can include changes in the fluids being processed by the system, mechanical changes arising from the failure or replacement of items of equipment or changes in the way the system is operated. It is vital to consider such changes in the light of the design philosophy of the system and to make sure that the changes do not lead to unacceptable consequences.

Two-phase relief flowrates. On the basis of comparisons with data currently available, including data generated as part of the project leading to the generation of these guidelines, the homogeneous equilibrium model (HEM) gives the best predictions for two-phase relief flows. The new API method (which is an approximation to the HEM) gives much better predictions than the original API method, but would not be expected to fit the data as closely as the pure HEM method (especially at high pressure) and the latter is the preferred choice. The HEM method deals naturally with cases where the flow upstream is gaseous and where condensate is formed. These cases may not be calculated accurately using the new API method. Since both the new API method and the pure HEM method involve flash calculations, there is little benefit from the simplification represented by the API method.

Lessons from experience. The English historian A.J.P. Taylor once remarked that "the reading of history is for entertainment only - nobody ever learnt any lessons from it!" Georg Hegel states that "The only thing we learn from history is that we do not learn from history". It is strongly recommended that the real incidents and near misses reported and analysed in these guidelines are reviewed in the hope that the quotations by A.J.P. Taylor and Georg Hegel will not apply to relief and blowdown systems.

Comments and revisions. The contents of these guidelines have been reviewed by the JIP participants. Although it is believed that the adoption of these guidelines will help to reduce the risk of accidents, the Institute of Petroleum, their agents and JIP participants cannot accept any responsibility of whatsoever kind for loss or damage or alleged loss or damage arising or otherwise occurring in or about premises, areas or facilities to which these guidelines have been applied.

It is intended that these guidelines will be revised when there are changes in related standards, industry practices or in the light of further practical experience. Comments on the document are welcome with a view to incorporating improvements at the next issue. Comments should be in writing and addressed to:

Publications Manager
The Institute of Petroleum
61 New Cavendish Street
London W1G 7AR
United Kingdom

ACKNOWLEDGEMENTS

The studies resulting in these guidelines were carried out in phases as part of a £364,000 Joint Industry Project (JIP) involving a number of companies and organisations. The Relief and Blowdown Systems (RaBs) project was initially managed by the Centre for Marine and Petroleum Technology (CMPT) and more recently by the Institute of Petroleum. These investigations were only possible due to the combined interest of the participants and their contribution is acknowledged. The following representatives on the Steering Group provided the decision making and technical direction for the duration of the project:

Amerada Hess Ltd.	Dr A (Andrew) Tilbrook
	Mr K (Keith) Hart
Anderson Greenwood Crosby Ltd.	Mr J-P (Jean Paul) Boyer
	Dr P (Paul) W Gayton (now a consultant)
ARCO British Ltd. (now bp)	Mr P (Paul) Wiseman
	Dr E (Edward) R Zamejc
BG Technology Ltd. (now Advantica)	Mr P (Peter) Cumber
Brown & Root Ltd. (now Halliburton)	Mr P (Paul) Horth
	Mr R (Ratnam) Sathananthan
Expro North Sea Ltd.	Mr D (Duncan) Cleland
Genesis Oil & Gas Consultants	Mr M (Martin) Brown
Granherne Ltd. (now Halliburton)	Dr M (Martin) Wills
Health and Safety Executive	Mr S (Stephen) Murray
Health and Safety Laboratory	Ms J (Jill) Wilday
Institute of Petroleum	Mr S (Sjoerd) F Schuyleman
Marathon Oil UK Ltd.	Mr A (Alan) Young
Mobil North Sea Ltd. (now ExxonMobil)	Mr M (Mike) Taylor
	Mr R (Roger) Billington
Shell Global Solutions	Mr L (Les) C Shirvill
Shell UK Exploration & Production	Dr M (Martin) Evans
	Dr S (Stephen) Northwood
Statoil	Mr O (Odd) Tveit
	Ms T (Tove) Gilberg
Total Oil Marine Ltd. (now TotalFinaElf)	Mr A (Alan) Brown
	Ms A (Alison) E Paterson

The content of this guideline document was developed from the input of a number of key individuals. The studies, contributions and experimental work were carried out on behalf of the JIP under various contracts and sub-contracts. The following were the key team members without whose invaluable work and dedication the project objectives would not have been achieved:

Anderson Greenwood Crosby	Mr J-P (Jean Paul) Boyer
BG Technology Ltd. (now Advantica)	Ms B (Barbara) Lowesmith
	Mr K (Keith) Armstrong
Brown & Root Ltd. (now Halliburton)	Mr P (Paul) Horth
Centre for Marine & Petroleum Technology (CMPT)	Mr M (Mark) Staunton-Lambert (Research Manager)
Consultant	Mr C (Colin) Weil (Project Manager)
Genesis Oil & Gas Consultants	Mr M (Martin) Brown
Granherne Ltd. (now Halliburton)	Mr A (Alisdair) Reid (Now Smith Rae)
IC Consultants Ltd.	Professor G (Geoff) F Hewitt (Editor)
Imperial College	Professor S (Stephen) M Richardson
	Dr G (Graham) Saville
Institute of Petroleum	Ms S (Sarah) Frost Mellor
Strathclyde University	Dr F (Frank) Crawley

The experimental equipment was designed and built at Imperial College and was largely operated by Dr G (Graham) Saville, Professor S (Stephen) Richardson, Mr S (Syd) A Fisher, Mr M A (Tony) J Meredith and Mr M (Malcolm) Dix who deserve our particular thanks. The assistance of Mr J (Jader) R Barbosa Jr. in carrying out the calculations for the standard cases as described in Annex G is also gratefully acknowledged.

1

INTRODUCTION

The oil and gas industry is involved in the processing of flammable and often toxic fluids, starting from the producing well through to the final products. Such fluids are inherently hazardous and great care has to be taken to ensure that the designs of any systems processing the fluids have adequate protection, allowing pressure relief and blowdown of the system as appropriate. These guidelines use the terms relief and blowdown as follows:

Relief: The fluid processing systems will be designed to withstand all expected operating pressures, but circumstances may arise when the fluid pressures within the system (in vessels, heat exchangers, pipes etc) rise above the system's lowest design pressure. In these circumstances, it is important to provide relief systems which automatically release the contained fluid. Typically, such relief systems might include bursting discs and relief valves and these systems would initiate relief at the set pressure without intervention from the operator.

Blowdown: In contrast to relief systems, blowdown systems are mechanisms by which the release of fluids from the system occurs as a result of operator action or as part of automatic control sequences. Typically, the system would be blown down (i.e. its vapour contents released by depressurising) as part of a planned shutdown or in response to an upset or emergency condition such as a fire which might weaken a plant component so that it fails below the relief system set pressure.

In both relief and blowdown systems, it is necessary to dispose of the fluid safely and this is typically done by burning it in a flare stack or venting to atmosphere.

There may be some confusion in the terms used in these guidelines. The terms and definitions used here represent industry usage in the United Kingdom at the time of writing but are not necessarily consistent with those used in other documents including international standards. For instance, the term **relief valve** has been used here rather than the term **safety valve**. There has been considerable discussion about the use of the alternative name safety valve. In the European standards, the term safety valve is used but we have chosen to retain the term relief valve as it more specifically indicates the function of the valve within the relief system (i.e. to relieve excess pressure).