ELIMINATION OF VALVE CONFINEMENT IN THE GAS DISTRIBUTION INDUSTRY: A QUALITY AND COST EFFECTIVE SOLUTION

Paula Campos Oliveira
COMGAS
Companhia de Gás de São Paulo
Alameda Santos, 1800
São Paulo - SP
01418-200 - Brazil
famcamp@ig.com.br

Adherbal Caminada Netto
University of São Paulo
Engineering College
Department of Mechanical Engineering
Av. Prof. Mello Moraes, 2231
São Paulo - SP - Cidade Universitaria
05508-900 - Brazil
adherbal@usp.br

Abstract. *The installation of valves in confined spaces may present a serious risk for operators. It is therefore required that new configurations for such valves be considered, in spite of the fact that the distribution network is over a hundred years old. In addition to finding technical solutions for such an improvemen it is also necessary to carefully consider the costs involved. This paper presents a study carried out for an utility company in Brazil, which is the largest investment of a major European energy company in Latin America, where possible solutions are compared. Following, the design for the adopted solution is described. A detailed cost analysis is then made. Finally practical restrictions and limitations for the implementation and the consequences thereof are discussed.*

Keywords*: cost, effectiveness, gas, pressure valves, quality.*

1. INTRODUCTION

An important concern in gas distribution is to avoid employees from suffering fatal accidents while working in confined spaces. Such activities present a high level of risk, and therefore must be carefully planned and carried out as discussed by Macedo and Oliveira (2006).

In accordance with Regulatory Norm Nº 31 (Brasil, 2007) a confined space is “any area not designed for human occupation with deficient ventilation means for contaminant removal, as well as without means for controlling the amount of oxygen present”.

Standard NBR 14787 (ABNT, 2006) defines a confined space as “any area not designed for continuous occupation, with limited entrance and exit accesses, and where the existing ventilation means are insufficient for contaminant removal, or where there is oxygen deficiency/enrichment”.

Some examples of confined spaces are silos, tanks, ship compartments, pipes, reactors, heat exchangers, galleries, etc. Figure 1 (a) shows an example of confined space where a 4” globe valve is installed, and Fig. 1 (b) how an operator has access to such valve.

(a)  (b) 

Figure 1. Example of confined space: (a) internal view; (b) external view.

An utility company in Brazil, which is the largest investment of a major European energy company in Latin America, established a project aimed at eliminating the confined spaces for 42 valves during the years of 2005 through 2007.

2. DESIGN FOR THE ELIMINATION OF CONFINED SPACES FOR VALVES

The first step taken for solving the confined space problem consisted in looking for possible technical solutions. At first it was considered to substitute *top entry* type valves for the existing valves. This solution, however, was deemed too expensive because it involved not only the substitution of valves, but also the extra costs incurred due to supply interruption and/or by-pass installation in order to keep consumers supplied in those instances where an interruption was by no means possible. Table 1 shows a cost comparison between two alternatives: substitution and valve adaptation.

Table 1. Comparison between alternatives for each valve.

Alternative	Cost (R$)
1. Substitution	150.000,00
2. Adaptation (*)	32.000,00

(*) Valve verification costs not included.

In view of the comparison shown in Tab. 1, it was decided to adapt each valve in a way that they could be operated from ground level. Such adaptation would be carried out without any supply interruption and therefore costs incurred would be smaller. A design contractor was then selected and the standard adopted solution is shown in Fig. 2.

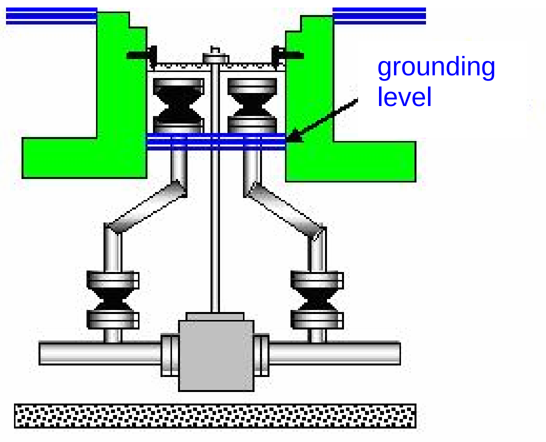


Figure 2. Solution adopted for the adaptation of globe valves in confined spaces.

It was also considered that in order to be capable of entering confined spaces people must have been adequately trained and prepared. Therefore another contractor was selected in order to provide the necessary specialized field personnel to enter the confined spaces and, under the supervision of the design contractor, gather the necessary information for design development.

For the initial phase 20 globe valves were selected. Then the 20 corresponding sites were visited by a team composed of representatives from the utility company, the design contractor and the field contractor.

Table 2 shows the costs for designing the 20 selected valves in accordance with the established scope, in addition to the costs involved in the field verification of those valves.

Table 2. Cost for designing 20 valves plus costs for field verification.

Description	Cost (R$)	Contractor
Field work	4.887,22	Field
Design – 1st installment -1/4	35.250,00	Design
Design – 2nd installment – 2/4	36.225,00	Design
Balance	69.525,00	Design
TOTAL	145.887,22	

Since eight of the 20 valves had reducers, it was also necessary to refer to the valve manufacturer in order to select reducers to comply with the new specifications. This was done by the design contractor and the supplied data were incorporated into the new valve designs.

3. REALIZATION OF THE NEW CONFINED SPACES DESIGNS

The adaptation work was planned to begin in October 2005. Accordingly, the responsible area in the utility company sent an order to the contractor in charge of the work realization and it was decided to begin with the reducer driven valves. The costs involved varied in accordance with depth of location as shown in Tab. 3.

Table 3. Costs for valve adaptation.

Depth of Location	Quantity	Cost (R$)
Less or equal to 1,50 m	unit	24.522,23
Between 1,51 and 2,00 m	unit	26.484,02

The utility company was in charge of purchasing the reducers and handing them over to the realization contractor. In September 2005 the specified reducers were ordered. A month later the manufacturer informed that the specified reducers were not the right ones and that another model had to be selected. The manufacturer was then requested to revisit the corresponding sites, accompanied by the client's confined spaces team, in order to precisely specify the required reducers. The design contractor was also invited to participate in the reducer selection process. Finally, after inspecting eight valves, VRSD 110 models were specified instead of the VRSD 90 models originally contemplated. The costs involved

Table 4. Unit cost and total cost (including taxes) for 8 reducers.

Product description	Unit cost (R$)	Total cost (R$)
Reducer VRSD 110 Vertical Torwell	9.847,00	92.167,92

The adaptation work was initiated by the contractor in two valves, but it was soon verified that the reducers' diameters were not adequate, as shown in Fig. 3, and the work had to be stopped until the reducers were machined for diameter reduction.

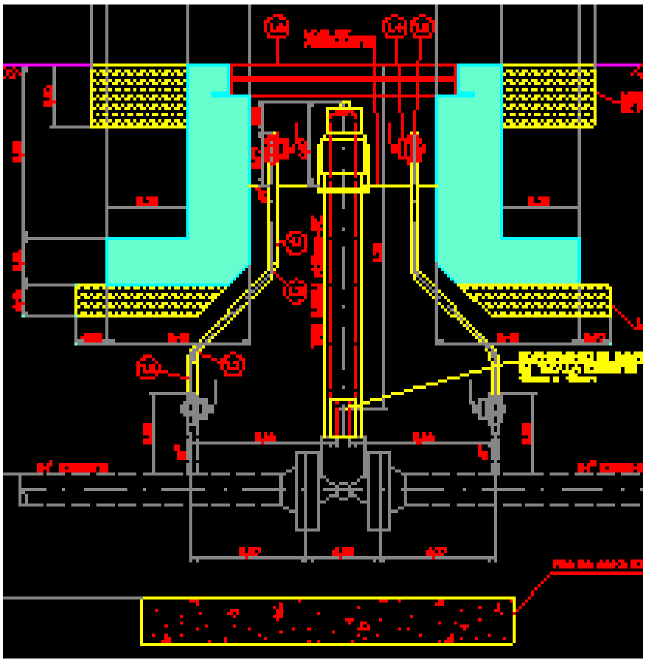
(a)

(b)


Figure 3. Reducers with larger than required diameters.

During the 18 day period of work interruption the valve openings had to be covered with metal plates, which produced noise and even a car accident. This fact generated a large animosity among residents and a safety and security strategy had to be developed in order to allow the adaptation work to proceed.

Although the work carried out in the first two valves could eventually be completed, it revealed a series of other design problems such as lack of dimensions, angle definitions, etc., and it was decided to postpone the adaptation of valves with reducers and begin working with valves driven by extension rods. The first two of such valves presented no problems and Fig. 4 provides an idea of the type of work that was actually carried out.

(a)


(b)


(c)


Fig. 4 Work phases: (a) working drawing; (b) extension rod and blow off valve tubes in place; (c) the completed work

The constructive requirements for both rod and reducer driven valves were similar, but during the work in the other valves driven by extension rods a number of flaws came up, which had not been observed in valves with reducers, such as mistaken addresses making valve localization impossible; errors in valve number and identification model, which rendered it very difficult to correctly define the lengths and angles of blow off tubing and therefore compromised field assembly; the match errors between valve heads and the dimensions and shapes of the ASTM A 278 316-L solid rods; in order to carry out the mechanical assembly it was sometimes necessary to increase the size of the concrete boxes or make other alterations not foreseen in the design phase, and since all the concrete boxes had been made from standard drawings such alteration generated new costs and delays.

Due to the detected flaws a confined space team was set up, the mission of which was to check *in situ* the design data as well as the actual situation of the remaining valves not yet adapted. Of the selected twenty valves, 17 were adapted and the respective confined spaces eliminated. One valve was not adapted due to its bad state of preservation. Another was found to be a polyethylene not a steel valve, thus requiring a new design. Finally another was not a globe valve, also requiring a different design.

4. COSTS VERSUS DESIGN FLAWS

Table 5 shows the total project cost for the twenty selected valves, including field verification, design elaboration, reducers purchase, and civil works.

Table 5. Total planned costs without flaws

Description	Quantity	Cost (R$)	Total cost (R$)	Contractor
Field work	20 valves	4,887.22	4,887.22	Field
Design – 1st installment -1/4	-	35,250.00	35,250.00	Design
Design – 2nd installment – 2/4	-	36,225.00	36,225.00	Design
Balance	-	69,525.00	69,525.00	Design
Reducer VRSD 110 Vertical Torwell	8	11,584.74	92,677.92	Valve supplier
Adapt. reducer driven valves	8	26,484.02	211,872.16	Civil works
Adapt. rod driven valves (average value)	12	26,448.05	317,376.60	Civil works
Licenses	12	5,289.61	63,475.32	Government and others
TOTAL			831,289.22	

The average adaptation cost, including field verification, design elaboration, and civil works would be approximately R$ 43,752. 06, that is, 36,72% higher than initially planned. Even that, however, is not the real value since it does not take into consideration a series of Quality Costs that were not measured during the adaptation process. The sources for such Quality Costs are shown in Tab. 6. For a comprehensive description of Quality Costs the reader might refer to Caminada Netto (2003).

Table 6. Source of project Quality Costs

Quality Costs source	Quality Cost category
Extra field work	Appraisal
Wrong selection of reducers	External failure
Incidents with local residents	External failure
Legal suit	External failure
Design flaws	Internal failure
Lack of blow off piping dimensions	Internal failure
Lack of assembly angles	Internal failure
Assembly problems due to concrete box dimensions	Internal failure
Wrong valve addresses, numbers and models	Internal failure
Lack of identification for blow off piping lengths and angles	Internal failure
Lack of match between rods and valve heads	Internal failure
Constructive requirements for the 20 similar designs	Internal failure
Approximately one year delay in work completion	Internal failure

The actual total cost for this project, considering non productive man hours, parts rework, wasted materials, design revisions, valve manufacturer visits, confined space teams extra inspections, etc., could not, however, be precisely calculated because none of the involved contractors possessed a cost control system capable of identifying and providing the necessary data.

After carefully considering all the practical restrictions and limitations for the implementation of the described project and the consequences thereof, it was suggested that extensive changes had to be introduced particularly as far as quality aspects and quality costs are concerned.

As a consequence, the solution for valve adaptation is currently being revised and all the involved parties have already contributed several improvement ideas. This includes the redefinition of project scope by those in charge of design, execution and maintenance.

5. CONCLUDING REMARKS

As a result of what has been described in this paper, it is possible to conclude that it is of utmost importance that contractors be led to implement cost control systems, capable of identifying and providing the necessary data for Quality Costs assessment and use as an indicator for continual improvement of project management and realization.

Future actions, therefore, should involve close cooperation between the utility company and its contractors in order to set up such reliable cost control systems for mutual benefit.

Finally it must be said that in spite of all the imperfections during the design and construction of the developed solution, the final result was evaluated as entirely satisfactory by the users, who affirm that the conditions for the realization of their works have improved due to increased easiness of access to the drive of the valves and the reduction of time for the completion of the necessary maintenance works. All activities are now carried through with total safety for the employees, not exposing them any more to a dangerous confined environment.

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7. RESPONSIBILITY NOTICE

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