GDF SUEZ

How to improve the efficiency of valve schemes ?

From a national policy definition to its field implementation: a global approach

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Abstract

This paper is focusing on the valves scheme project managed by the main French distribution operator, GrDF, and launched 2 years ago with the help of GDFSUEZ R&I Division. The main issue of this ambitious but complex program is to improve the efficiency of the number and location of the security valves on the distribution network so as to find the optimal tradeoff between "safety, quality of gas providing and annual maintenance costs". The expecting consequences are cutting maintenance costs up to 50% while insuring higher security standards.

To implement this project on the field, GrDF has worked on the following steps :

- First, define a national policy that is to say the conception rules that all the sets of security valves have to respect in order to guaranteeing that the final design of all networks satisfies the operational and safety requirements while minimizing costs

- Then, its implementation: design optimization and field work. To succeed on this step, help making decision tools and field requirements have been made in order to provide concrete support for change to study engineers and operators.

To succeed on this task, GrDF and GDF SUEZ have worked together through an original approach. The first aim has been to get a better understanding of all the aspects of the problem, underlying questions and impacts and concerns for each participants (field operators, study engineers and policy experts). The next step has been to provide solutions for each part of the problem (design, field and politic), controlling the interactions between them. And all this consequent knowledge has finally been used to put in place some help making decisions tools to provide concrete support for change on the field.

The valves scheme project is scheduled to be finished in around five years.

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I. Introduction

GrDF, the main French gas distribution operator, maintains, develops and operates more than 110 000 miles of pipelines. It covers 75% of the whole territory, providing gas to 9 200 municipalities, mainly big French cities with complex design network. The challenge in that task is to be able to guarantee the network integrity, the safety of goods and people, a proper communication level with the local authorities, while controlling the investments and maintenance expenses.

One current big issue regarding the global maintenance cost concern the security valves used on distribution network to stop the gas flow during an emergency situation. As illustrated on the *Figure 1* below, these valves are installed all over the distribution networks such as covering each part of it, regarding some constraints like the pressure level and the density of the consumers in the zone.

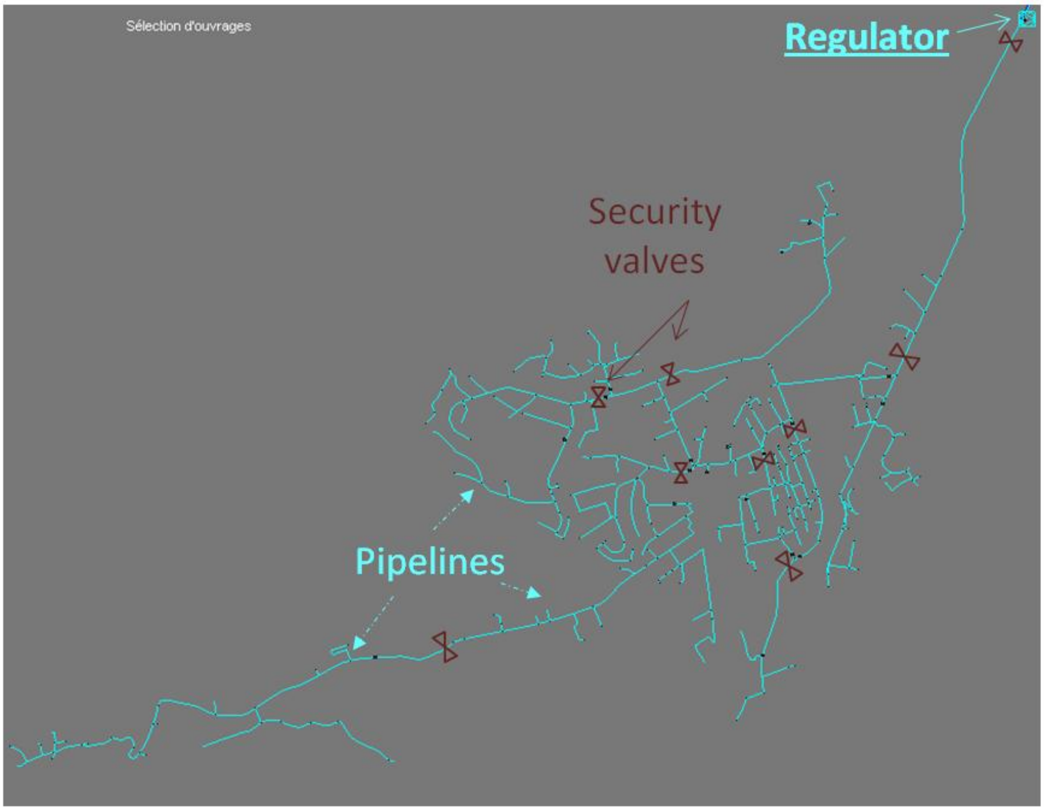

Figure 1: example of one French distribution network equipped with security valves, illustrated in red.

To consider some representative figures, the French gas distribution networks approximately have a cumulated number of 300 000 valves, and the corresponding annual maintenance cost, including preventive and corrective aspects, is 6.5 million Euros.

Hence the main question which has to be considered is : is it possible to improve the risk management while cutting the maintenance costs? As precised in the following paper the answer is yes thanks to the valves scheme program. The next part explains what is exactly this project and what are the issues. The section III presents the global process put in place during this program from the national policy definition to its field implementation. And the last part gives a feedback, explaining in details the original and collaborative approach used by GrDF and GDFSUEZ R&I Division to reach these objectives.

II. An ambitious but complex program : the valves scheme project

First let us explain what is the valves scheme project: the global goal, the different issues and why it is a complex program.

1. A global issue about security, quality of gas providing and annual cost

The main objective having security valves on distribution network is to be able, in case of an emergency, to quickly interrupt the gas source, by shutting off a set of valves.

As shown in *Figure 2* below, in case of an incident on the pipeline *a*, the valve *v* has to be closed so as the gas flow coming from the regulator is stopped.

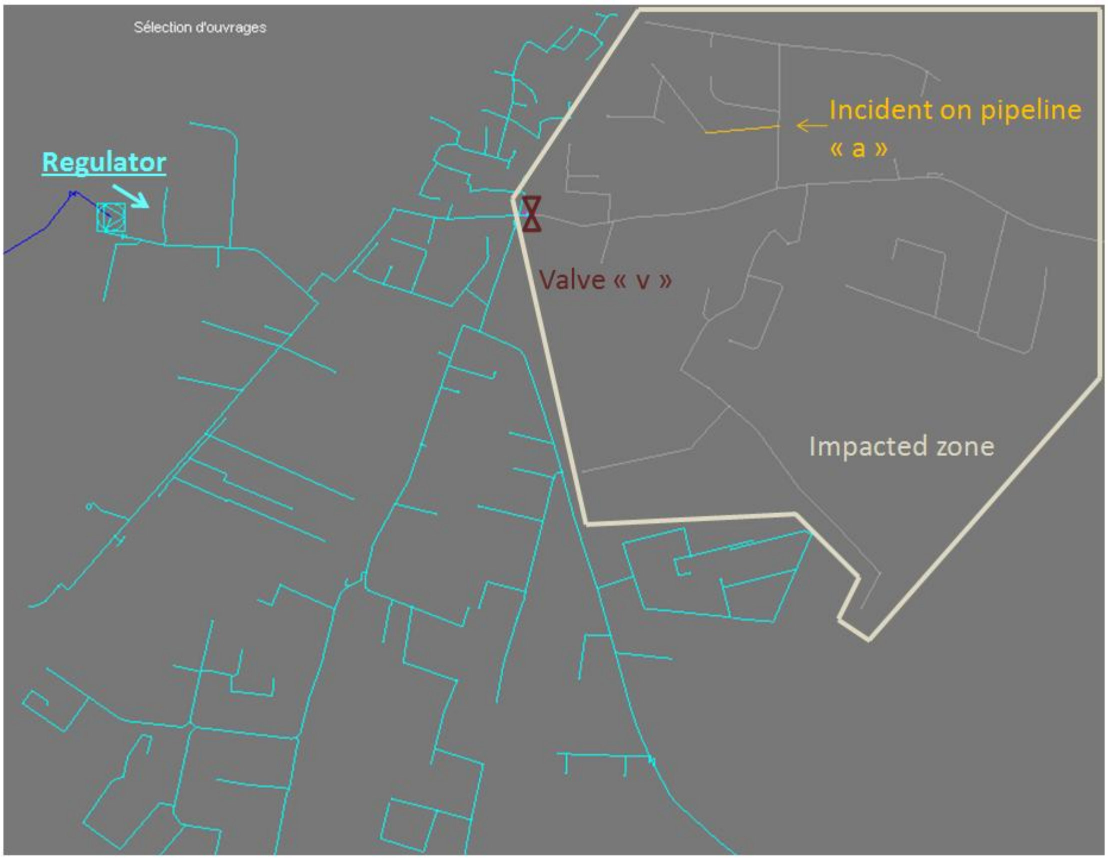

Figure 2: illustration of an incident situation on one French distribution network.

Then, the gas volume considered in grey on this figure is trapped and the consumers on this zone risk to be not any more provided in gas. To control the safety of goods and people, this contained gas has to be vented to the atmosphere as fast as possible. To do so, field crews usually simply use the gas consumption on the zone and the intensity of the leak. In worst cases, if they need to speed up this blowdown process, they will use a specific material shown in the following *Figure 3*.

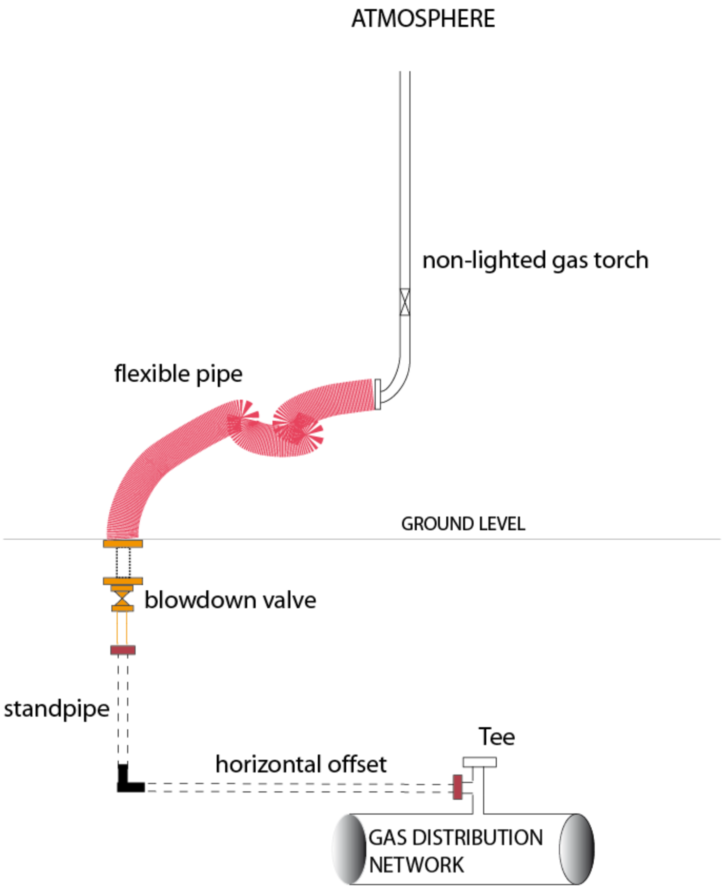

Figure 3: description of blowdown equipment used by distribution crew if vent process needs to be speed up.

The gas inside the network is then vented to the atmosphere through a specific blowdown equipment made of:

- a steady part: complete part of the network made of a tee plugged on a pipeline, a global offset and a blowdown valve
- a mobile part: part added by the distribution crew and made of a flexible pipe plugged to a non-lighted gas torch

Consequently, the choice of the number and the location of the security valves for each part of the distribution network affects the balance of the following scheme (*Figure 4*) :

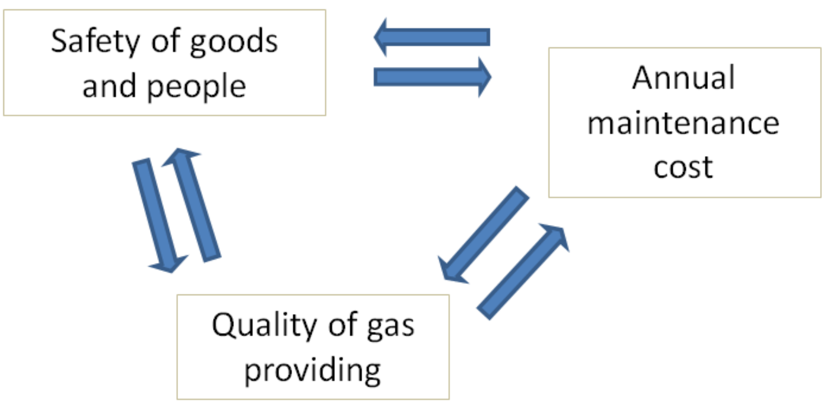

Figure 4: impacts of choice of number and location of security valves on distribution networks.

Indeed, the characteristics of the sets of valves will have the following impact :

- On the safety of goods and people during emergency situation through:
  - The response time which is the time required to stop the gas flow by closing the security valves. More there are security valves to be closed, more the response time is important.
  - The blowdown time which is the global required time to get the zone safe i.e. empty of gas. This parameter depends on pressure and volume of gas which has to be blow downed. More the impacted zone is wide, more the blowdown time is important. And the impacted zone is directly defined via the location of security valves.

- On the quality of gas providing since valves location determines the number of clients being shut down. More the impacted zone is wide and with high density, more the number of impacted consumers is important.

- On the annual maintenance cost since all the strategic security valves have to be maintained once a year.

Consequently, doing a valves scheme means designing the sets of security valves on distribution networks by determining their optimal numbers and locations. This is very important regarding the security of goods and people and to guarantee a certain quality level of gas providing under the classical constraint of minimizing the annual maintenance costs.

Before going further, let’s explain the notion of blowdown block useful for the following sections.

2. The blowdown block notion

As illustrated in the *Figure 5 below*, considering the sets of valves on a global network, we can create a partition of this network in many zones, called **blowdown blocks**.

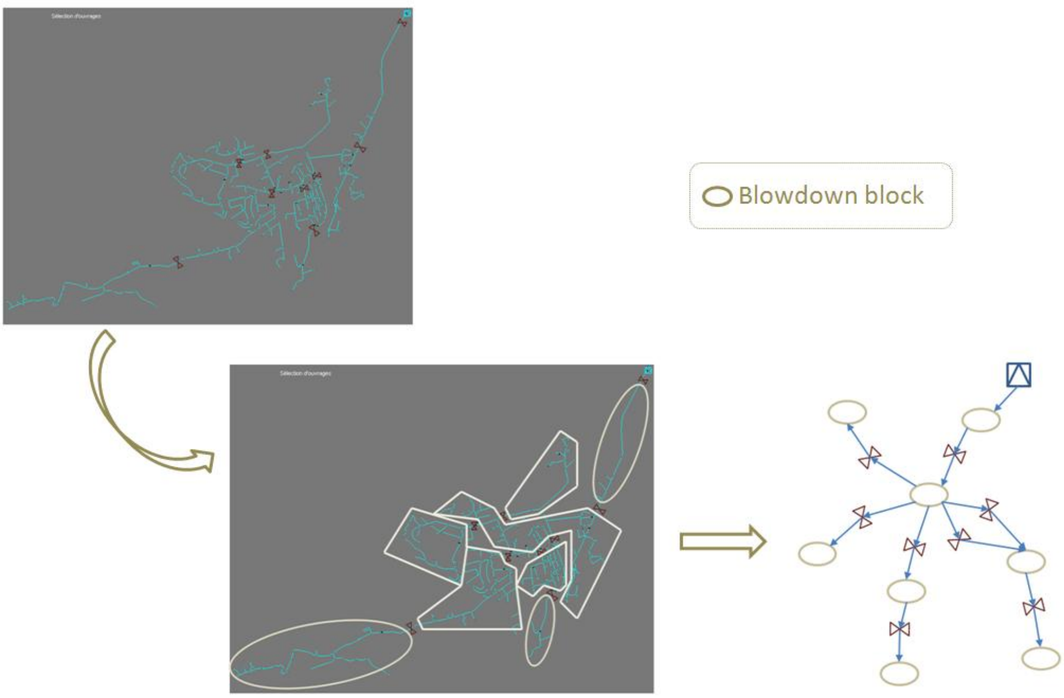

Figure 5: illustration of blowdown block notion

Indeed, if we close all the security valves of the whole network, then we can gather all the pipelines trapped by the same valves in one block. Doing it for each part of the network, allowed us to find a partition in blocks of it. Each block get its own characteristic : volume of gas, number of clients, total length of pipelines… This "blowdown block" notion will be useful in the following parts.

The next question which as to be considered is now : how are currently designed these blowdown blocks? Is this design optimal considering the constraints "security, quality of gas providing and costs"?

3. Is the current designing optimal considering the global constraints?

The current blowdown blocks on French distribution networks have been designed gradually over time with the evolution of the networks development and under the following constraints :

- Maximal number of customers impacted in the gas providing
- Maximal number of security valves to close
- Maximal length of pipelines contained in the block

Then, for each evolution of design, study engineers optimize locally to determine if new valves are necessary or not. Today, 300 000 valves are maintained once a year. Since the optimization has been local and not global, some of these security devices may not be useful any more. However, it represents an important annual cost in maintenance but also a risk of having bad maintained valves difficult to close during a real incident, due to the huge amount of maintenance work. Then, having more and more security devices as valves on the network doesn't necessarily mean a better security level. An optimal trade off can be found, minimizing both the annual cost and the risk level, considering a global optimization.

Consequently, the current question is to rethink the whole valves scheme to get the optimal ratio "security / gas providing level / cost". In other words, that means to optimize globally and not any more locally. That also means, if necessary, casting doubts on the current constraints of designing. This global project makes also sense since the French distribution networks are not evolving so much anymore.

Before describing the process followed by GrDF to reach this objective, let's explain the complexity of such a topic.

4. A complex issue

Three main aspects make this valves scheme issue a complex one.

a. Big variety of people involved

The first particularity is the big variety of people involved. Indeed, each layer on GrDF structure will be impacted. In first, the experts who are in charge of defining the national policy and the constraints of blowdown blocks design. They will be involved since these constraints will have to evolve. In second, the study engineers who are in charge of designing and optimizing all the distribution networks. They will be impacted since they are in charge of determining which valves will be kept, which ones will be abandoned and where it is necessary to add new ones. In third, the field crews who will be in charge of implementing the engineers requirements on the field. But also, some jurists to check on the acceptability of the new national policy and so on.

This diversity of people involved will make it complex since the concerns and expectations of each participants is different.

b. Important investments

The second specific point is that realizing this goal remains very demanding as it cannot be achieved without important investments both in studies and field operations. Indeed, 110 000 miles of pipeline will have to be studied and even if a lot of valves will be abandoned, which is costless, some new ones will have to be installed at an optimized location, which is an expensive field operation. Let us precise that this is not incoherent with the initial aim since big investments will be made once but will allow to decrease the annual maintenance cost, which are paid every year.

c. Very tight time schedule

The last particularity of this issue is the time schedule. The whole program duration is set to around five years, studies and field implementation included. This planning is very short considering that is concerns 75% of the whole French territory.

We now know what is the valves scheme program. Then let us describe the process followed by GrDF to deal with this ambitious project.

III. A global process : from the definition of a national policy to its field implementation

a. Definition of a national policy

The first phase of this process has been to the experts to define a set of national rules and guidelines which will lead the global optimization of the blowdown blocks design and guarantee that the final design of all networks satisfies the operational and safety requirements.

It is based on the previous valves scheme policy and is improved taking into account some new criteria to answer to the global optimization targets "security / gas providing level / cost". This policy also sums up the consequences of this new design on the operational strategy. Then study engineers and field crews can and have to refer to this document when they deal with valves scheme issues.

The criteria to apply to design blowdown blocks with respect of the pressure level have been finally defined such as:

- A maximal number of customers impacted in the gas providing
- A maximal number of security valves to close
- A maximal length of pipelines contained in the block
- A maximal volume to blowdown

More explanations are given in paragraph IV.b regarding how GrDF and GDFSUEZ R&I Division have worked together to carry out this first phase.

b. Complete diagnosis of weaknesses & optimization of distribution networks

The second step of the process is to optimize globally the existing distribution networks regarding the theoretical rules given by the national policy. That means make a complete diagnosis of weaknesses in determining for each existing blowdown blocks if:

- it is already optimized. This case is costless. No action is required

- it is over or under designed for at least one of the criteria. In this case optimization is required. It can lead to valves removal and/or installing. This optimization to be global has to be made taking into account the neighborhood of the current block

This step is managed by the study engineers and the final report of this step is the list of valves to remove and the list of valves to install with the location information. In order to guaranteeing consistency between theoretical and field points of view, the final report is given as proposal to the field crews. A collaborative phase is then put in place to converge on a final solution.

c. Implementation on the field

The last step but not the least, consist in implementing on the field the optimized scheme solution. This is directly managed by the field crews. In reality, in the case of valves removal, few actions are required : the valve is just abandoned and not physically removed. But concerning valves installing, field crews are managing the complete earthworks. In both case, they are also in charge of updating the information in the GIS.

As precised in paragraph III.a, the new design policy has also impacts on the operational strategy which is the way field crews have to operate the network, overall during emergency situations. Then they also have to familiarize themselves with this new operational policy.

We now know how did GrDF organize itself to deal with this ambitious project. Then let us give a feedback in explaining more in details how GrDF and GDFSUEZ R&I Division have worked together to carry out all the different phases of the valves scheme project.

IV. GDFSUEZ R&I Division/GrDF : an original, global & collaborative approach put in place to succeed in this task

As a neutral entity of GDFSUEZ, the Research and Innovation Division offers its expertness to all the subsidiaries of the group. In the valves scheme project, Research and Innovation Division gave support and advices to GrDF thanks to its knowledge about dynamic flow, network design and help-making decision software development.

In the following part will be explained this approach.

a. Definition of the national policy

Defining a national policy for valve scheme design means defining optimal criteria for security, gas providing level and cost aspects but also taking into account the constraints of field implementation.

It raises the following questions: How must the distribution networks be designed to guarantee emergency response time? How many valves must be kept, referenced and maintained? What operational strategy must be implemented? What kind of tools must be given to operators, study engineers? which flexible pipe must be used? what is the size of the orifice through which the gas must be vented? How big can be the zone under supplied with gas so as to be managed by field crews in a moderate time?

As you can see the range of questions is very wide. It goes from safety requirements to material definitions via gas providing considerations. The tricky point is that each answer has an influence on the whole solution, therefore no aspects can be left apart. Consequently it has been decided to use a **sequential approach**. The next two paragraphs explain how the conception rules have been set regarding the aim of global trade off between safety measures, gas providing level and global cost. The last section describe how the aspect of field implementation has been managed.

b. Identification of consistent safety requirements and definition of design criteria that fit these requirements

In that case, after field considerations during emergency situations, it has been decided that the safety criteria will be:

- The response time: the global required time to stop the gas flow i.e. to close the security valves
- the blowdown time: the global required time to get the zone safe i.e. empty of gas
- the maximal gas flow at the top of the torch: it affects the radiation zone and so as the security perimeter required to protect people around

In order to define the conception rules that let us satisfy the safety criteria, a precise conception analysis has been done on more than ten representative networks. The goal of this analysis was to compute the potential blowdown time, the maximal gas flow and the number of security valves obtained for each part of the network.

This has been done by making an extensive use of a graph analysis tool specifically developed by the R&I division for that purpose, as shown in the *Figure 6* below.

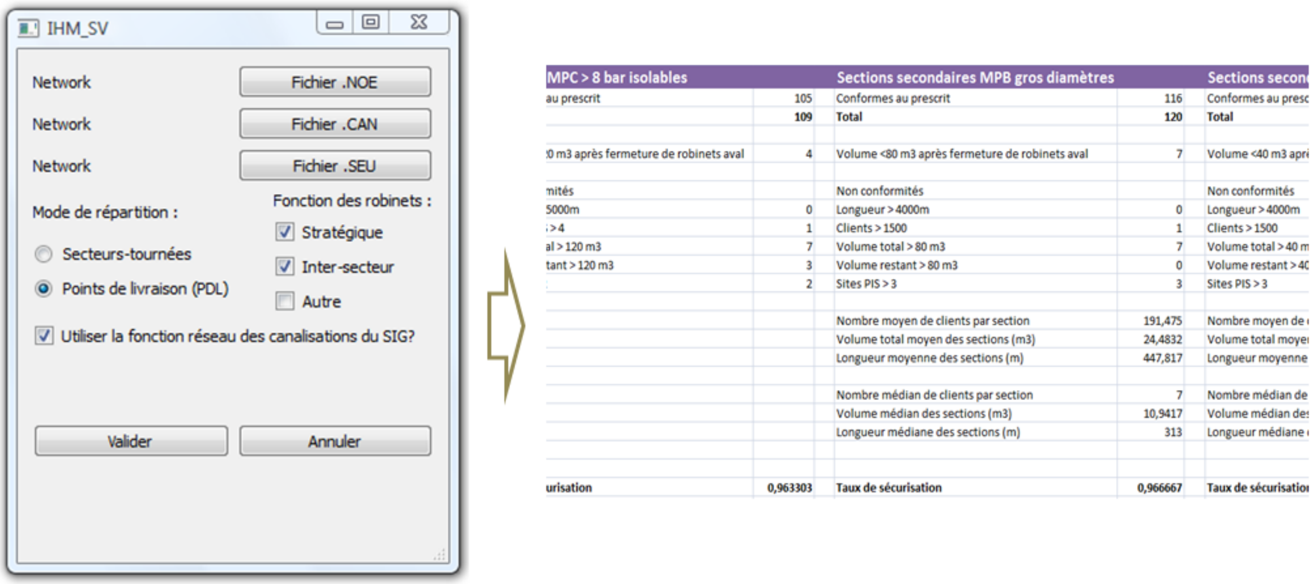

Figure 6 : screen shot of the graph analysis tool dedicated to valves schemes diagnosis

This graph analysis tools can process up to 40000-pipe network in a few seconds. It computes for the input network, the complete partition of blowdown blocks and its characteristics : number of security valves, blowdown time, maximal gas flow, number of impacted consumers, total length…

Thanks to this analysis, a network segmentation based on a combination of pressure level and diameter has been defined and for each segment a maximum gas volume has been set in order to verify the safety criteria while optimizing the cost of redevelopment.

These maximum values for volumes are now part of the conception criteria used by study engineers to check whether their valve schemes conform to national rules. Notes that this criteria is a new one but completes a previous existing criteria around response time and cost: the limit of number of security valves to close during emergency situations.

c. Considerations about gas providing level

As precised previously, valves scheme design is a global trade off between safety measures, gas providing level and global cost. Then, what are the conception rules regarding gas providing level? In that case, they are the same as for the previous national policy: limit of maximal number of consumers impacted with gas providing in case of emergency situations. This criteria takes into account both gas supplying and cost aspects. Indeed, this maximal limit has also been set to minimize the number of field crews involved in reactivating the consumers regulator stations closed due to low pressure.

d. Definition of the operational aspects as safety strategies to be defined, material to be used, tools to be developed

The last phase of our sequential approach was to deal with operational aspects, and especially to answer the following questions: what can be done to help study engineers carry out the network analysis? Are flexible pipes and gas torches well suited to meet the safety criteria? And finally how can an operator speed up the blowdown process?

Firstly, to help study engineers we have adapted the graph analysis tool that we used for our own studies described in previous paragraph b, so that its results could be directly integrated in the optimization process.

Secondly, regarding the field implementation of safety criteria, the current problem is that blowdown time is highly dependent on what kind of material is used to vent gas to the atmosphere. Then considering the existing material, we have identified sets of orifice diameters that should not be used for gas venting because they induce too important gas flow or too slow blowdown process. We have also made some recommendations regarding the use of flexible pipes: we are developing a new flat flexible pipe that will reduce the pressure losses and thus that will lower the blowdown time.

At last, to help the operators identify the best intervention strategies in term of blowdown time, response time and number of clients being shut down, we have developed a new feature in our simulation software, CARPATHE v5, the reference tool for GrDF operators.

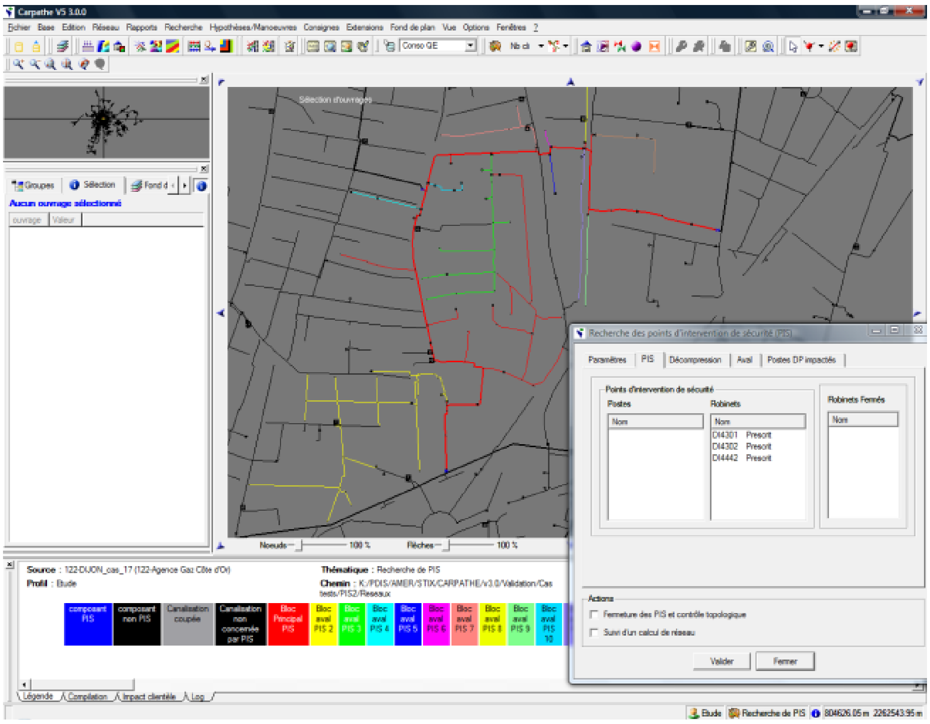

Figure 7 : screen shot of the CARPATHE v5 feature helping operators to define the best intervention strategy

The above *Figure 7* is a screen shot of the current version of this help-making decision software: colored pipelines represent blowdown blocks for an incident on a given pipeline whereas the dialog box gives to the user the strategic security valves that it is necessary to close to stop the gas flow.

To provide support for change on the field regarding the new policy, a new module is being developed to help operators making operational decisions during emergency situations: which valves do they have to close in first step to stop the gas flow? Considering the leak alone, how long will last the blowdown process? How much adding a mobile material (flexible pipe and gas torch) will be useful to speed up the process? Which downstream valves can be closed to decrease the gas volume and so to speed up the blowdown process? How many customers will be shut down and when? Ect...
This module is scheduled to be available on field next year.

e. Conclusion

This global approach has made us tackle all aspects of the problem while providing solutions for each project participants: from operators, to policy experts. Its implementation will lead to new network designs, cutting maintenance costs up to 50%, according to forecasts, while insuring higher security standards.

V. Conclusion

Decreasing annual maintenance costs up to 50% while insuring higher security standards has been possible on the French distribution network thanks to the complex but ambitious project of rethinking the valves scheme.

How? Thanks to the original, global & collaborative approach put in place by GrDF and GDFSUEZ R&I Division. This teamwork leads to the following main actions:

- A new national policy and in particular a new and objective conception criteria for blocks has been defined. It is based on a maximum gas volume depending on the pressure level and verifies the safety criteria while optimizing the cost of redevelopment

- A new way of optimizing the design of blowdown blocks, globally and not any more locally, is used with the help of a dedicated analysis tool

- A concrete support for change on the field has been provided to the operators regarding the implementation of this new policy: recommendations of new and adapted material, development of help-making decision module to find the best intervention strategies, ect…

This program is currently running and is scheduled to be achieved in few more years.