Water-mist systems in mass-production industries: A successful application to a tissue-converting plant

Paolo E. Santangelo [a], Paolo Tartarini [a], Massimiliano Bettati [b], Luca Tarozzi [b], Silvano Pane [c]

[a] *Dipartimento di Ingegneria Meccanica e Civile (DIMeC), Università degli Studi di Modena e Reggio Emilia, Modena, Italy*

[b] *Bettati Antincendio S.r.l., Reggio Emilia, Italy*

[c] *T.A.S.I. S.n.c., La Spezia, Italy*

CASE STUDY: TISSUE-CONVERTING PLANTS

MAIN CHARACTERISTICS:

- The machineries are very expensive and complex;
- The considered plants operate 24/7;
- The converted material (cellulose) is of low unit price;
- The output products (handkerchiefs, napkins, kitchen towels, paper sheets, toilet paper, etc.) have very low unit value;
- The daily output is very high, as consistent with mass-production industry: the real value stands in the production rate.

TO BE PROTECTED: THE WORK STATIONS

CONVERTING PROCESS

MAIN FEATURES:

- The converting process consists in obtaining the commercial products (toilet paper, napkins, …) from a main paper reel.
- This conversion is achieved by a rotary machine, that is operated within an enclosed space.

WHAT'S IN?

✓ Paper rolls;
✓ Cellulose powder;
✓ Electric motors;
✓ Liquid colors (flammable);
✓ Control panels.

EXISTING BACKGROUND -1-

Lucca, brucia la Delicarta Miliardi di danni

il Tirreno — 12 marzo 1998 pagina -1 sezione: PRIMA

LUCCA - Un grande incendio è scoppiato alla Delicarta di Tassignano, nei pressi dell'autostrada Firenze-Mare. Le fiamme, altissime, erano visibili in tutta la piana fino a Montecatini e sono accorsi decine di vigili del fuoco. I danni sono di miliardi. In cronaca

PERINI JOURNAL

N° 22 - MAGGIO 2004

IL MONDO DEL TISSUE

"31 maggio 1988 Soffass completamente distrutta da un incendio: in una nottata se ne andò tutto il parco macchine, non si salvò neppure un pacco di prodotto finito, l'immobile distrutto. Una campagna pubblicitaria, quella del marchio Regina, appena cominciata e un momento in cui commercialmente stava decollando. Tutti i dipendenti disperati un disastro di tale entità non si era mai verificato in Lucchesia.

RAPPORT D'ÉTUDE 24 / 06 / 2008

DRA-08-98215-08087A

Etude des risques incendie et ATEX des lignes «rouleaux finis»

Client : DELIPAPIER

Deux incendies ont eu lieu dans les six derniers mois sur deux de huit lignes de production de rouleaux finis. L'un d'entre eux a mené à la destruction de l'intégralité de la ligne de production.

EXISTING BACKGROUND -2-

RAPPORT D'ÉTUDE 24 / 06 / 2008

DRA-08-98215-08087A

Etude des risques incendie et ATEX des lignes «rouleaux finis»

Client : DELIPAPIER

5.1.2 Analyse des risques incendie

Les risques d'incendie sont principalement dus à des dépôts de poussières sur des surfaces chaudes. La poussière de cellulose étant un bon isolant thermique, le dépôt empêche le refroidissement de la surface. La température d'auto inflammation en couche de 5mm de la cellulose est de 370°C.

Un dysfonctionnement d'un équipement ou de la ligne elle même (comme cela a été probablement le cas lors de l'accident sur la ligne 7) peut également être à l'origine d'un incendie.

La présence de poussière de cellulose sur dans quasiment l'intégralité de la ligne de production, ainsi que la vitesse rotation des cylindres (turbulences locales) sont des facteurs favorisants une expansion très rapide de l'incendie. La présence potentielle d'une quantité importante de cellulose sur la ligne augmente la gravité en cas d'incendie.

The fire events appear to be mainly due to:

- cellulose powder lying on to hot surfaces (auto-ignition phenomena);
- machine malfunctioning, thus resulting in cellulose-powder ignition.

The large quantity of cellulose powder and the high rotation velocity may yield to fast-growing fires.

The fire-risk analysis has emphasized the need for a fire-protection system within any work station

FIRE SAFETY OBJECTIVES

- Early system activation:

  need for an effective fire detection system;

- Fire suppression:

  reduction of the heat release rate and prevention of fire re-growth to prevent or limit damages to the machineries and limit the business interruption;

- Temperature control:

  aim at preventing flashover and limiting damages to the machineries, thus limiting the business interruption as well.

A HIGH-PRESSURE WATER-MIST SYSTEM WAS SELECTED

WHY WATER MIST?

- The space is enclosed (compartment fire);
- The space is not sufficiently tight to allow a gas-based firefighting system;
- Potential human beings may be present inside the work stations, thus discouraging from employing CO_2-based systems;
- A sprinkler/deluge system would imply longer delay times to re-arrange full-load operations, even because of an excessive wetting of the involved machineries.

FIRE EVENT IN GERMANY: A REFERENCE CASE

April 2010: a fire occurred in a tissue-converting plant in Germany, where traditional sprinklers were employed as the fire-protection system. The fire source was located within an embosser: the sprinkler-system successfully operated, but four days of cleaning operations were thereby required. The plant experienced a full business interruption during that time.

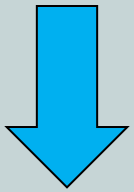
THE CHOSEN SYSTEM: GENERAL FEATURES

The employed system consists of the following components:

1. A series of **open** water-mist high-pressure **nozzles**;
2. A detection system designed as based on a **2-detector confirmation**: both flame detectors and rate-of-rise heat detectors with fixed temperature (57 C) are inserted;
3. Available **manual discharge**, as a possible option for the involved personnel.

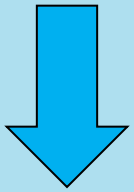
DESIGN GUIDELINES

CEN/TS 14972



PERFORMANCE-BASED TECHNOLOGY

The present case is neither included nor considered as a specific scenario within the standard CEN/TS 14972

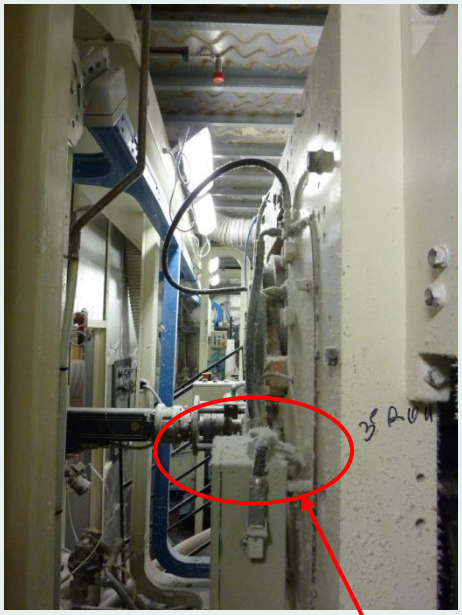


GENERAL GUIDELINES: **ANNEX B**

EXPERIMENTAL TESTS

Combustible material: cellulose powder tends to lie onto the solid surfaces of the machineries.

Production station



Test facility (28 m^2, 91 m^3)

Cellulose powder

METHODOLOGY: PROPERTIES AND PROGRAM

Cellulose powder characteristics:

- ✓ Density: 60 kg/m^3
- ✓ Lower Heating Value: 16.1 kJ/g [1]
- ✓ Quantity: 0.13 m^3

[1] D. Drysdale, An introduction to fire dynamics, Wiley & So., 2nd ed., 1998.

Test program:

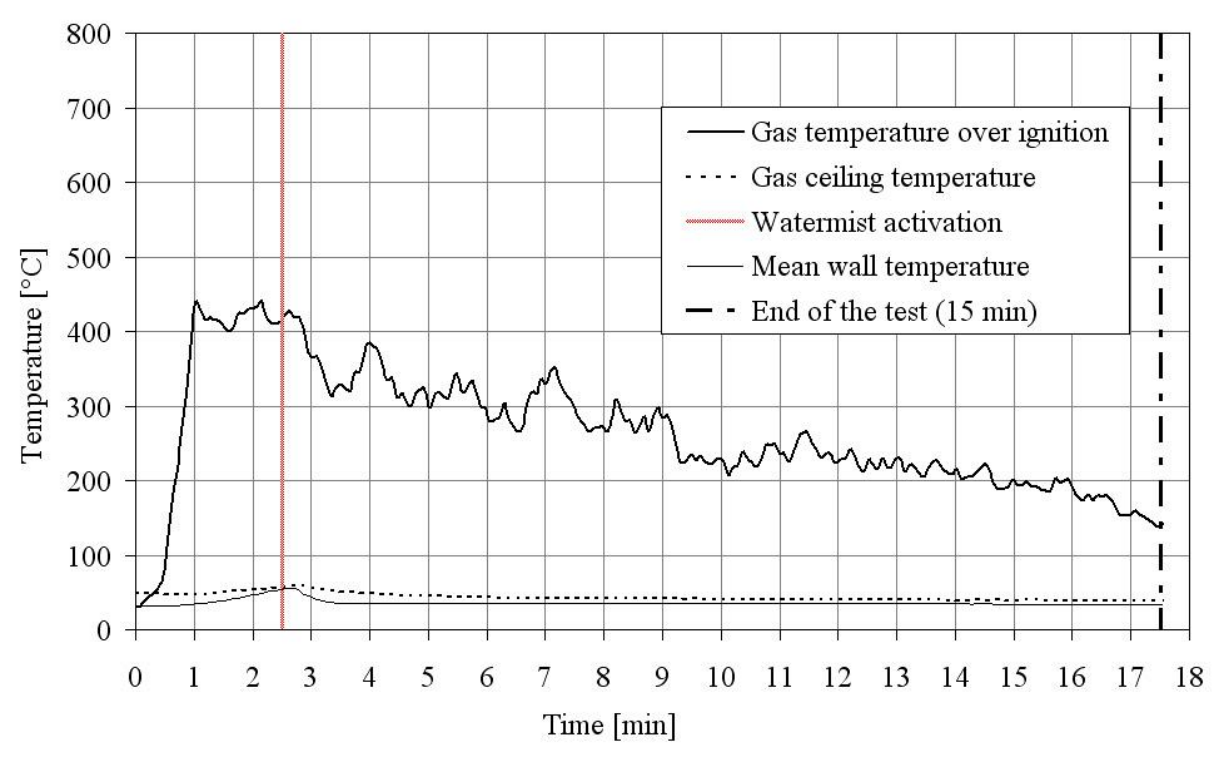
- ✓ Obstructed and non-obstructed fire
- ✓ Ventilation conditions, VVR (vent-to-volume ratio) = 0.05 m^2/m^3
- ✓ Pre-burn time: 150 s

	Q [L min^{-1} m^{-2}]	Obstructed fire	Ventilation
Test 01	0,5	Yes	No
Test 02	0,9	Yes	No
Test 03	0,9	No	No
Test 04	0,5	Both	Yes

EXPERIMENTAL TEMPERATURE PROFILES – TEST 01

Discharge density: 0.5 L min^{-1} m^{-2}

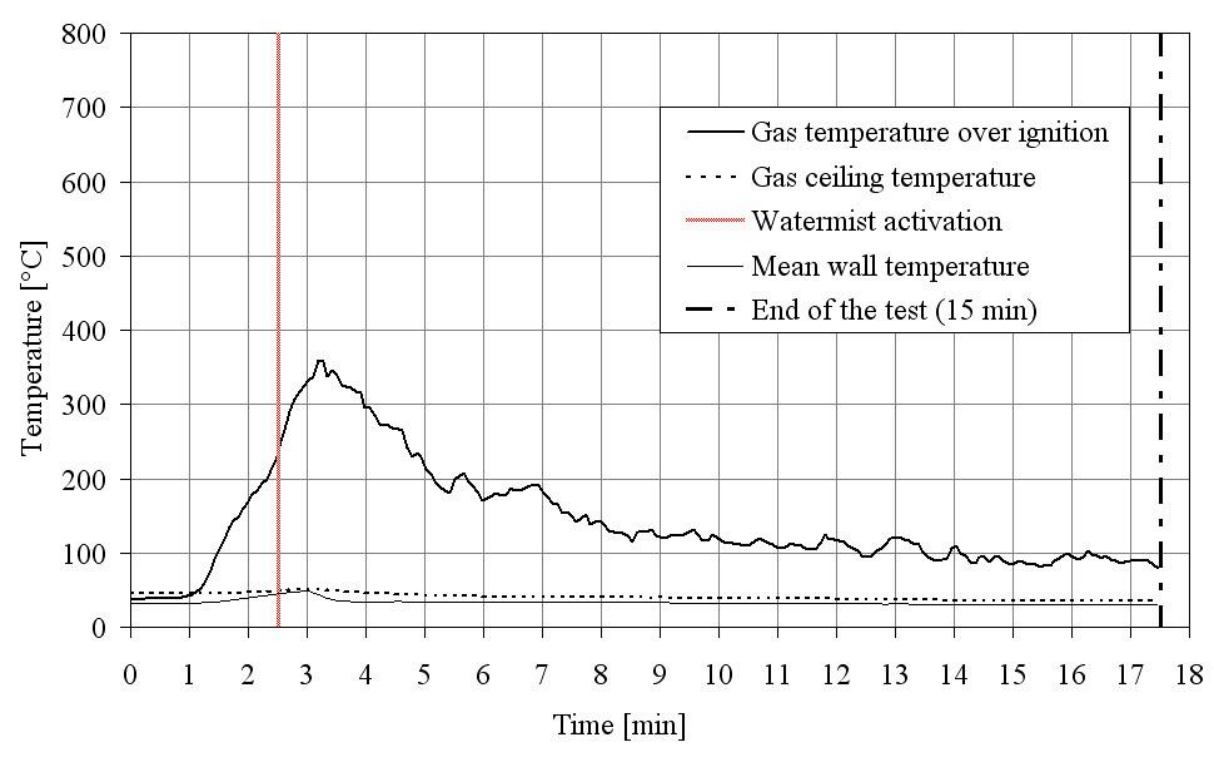
- ✓ obstructed fire;
- ✓ no ventilation was considered;
- ✓ pre-burn time: 150 s;
- ✓ 0.13 m^3 of cellulose powder.



EXPERIMENTAL TEMPERATURE PROFILES – TEST 02

Discharge density: 0.9 L min^{-1} m^{-2}

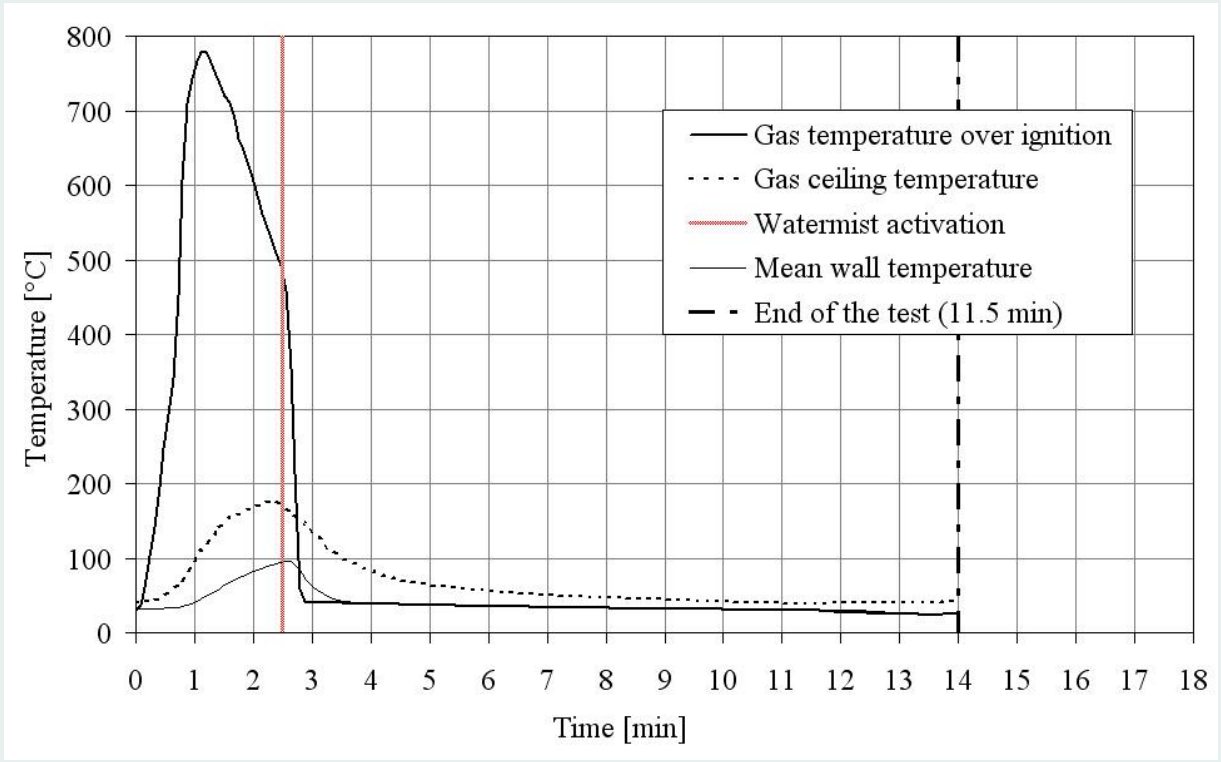
- ✓ obstructed fire;
- ✓ no ventilation was considered;
- ✓ pre-burn time: 150 s;
- ✓ 0.13 m^3 of cellulose powder.



EXPERIMENTAL TEMPERATURE PROFILES – TEST 03

Discharge density: 0.9 L min^{-1} m^{-2}

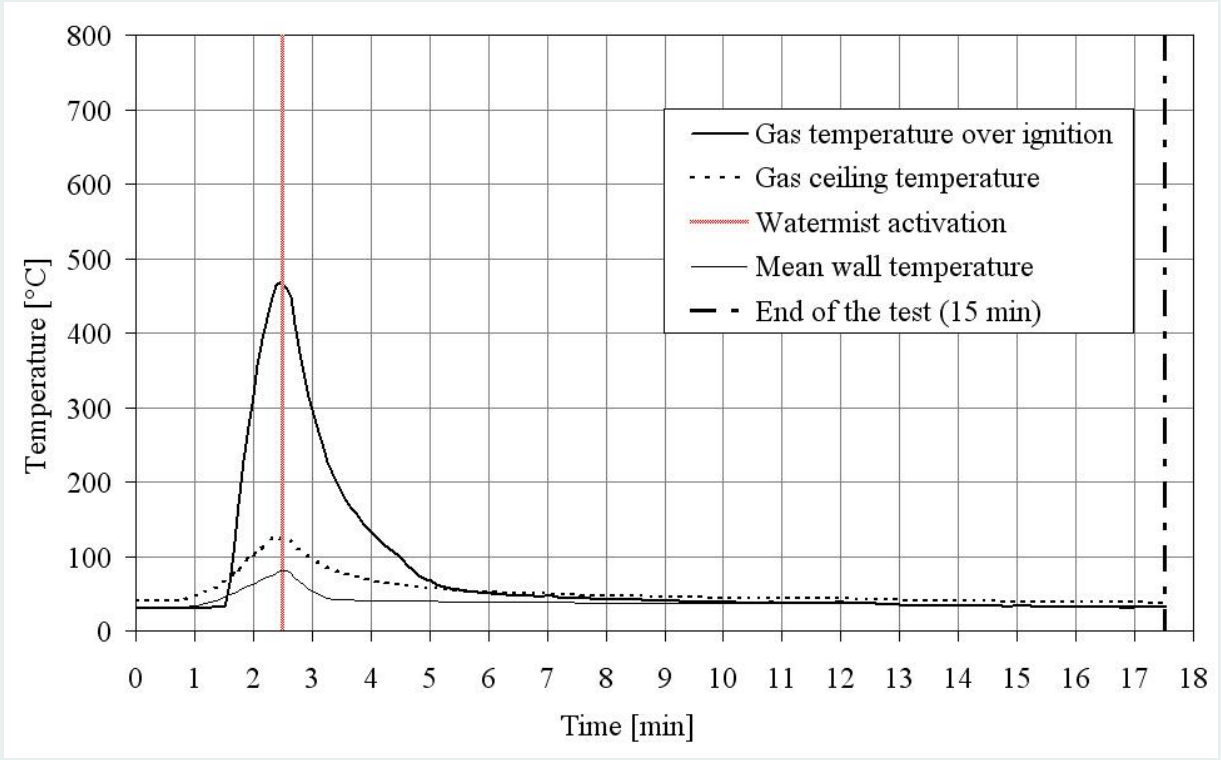
- ✓ non obstructed fire;
- ✓ no ventilation was considered;
- ✓ pre-burn time: 150 s;
- ✓ 0.13 m^3 of cellulose powder.



EXPERIMENTAL TEMPERATURE PROFILES – TEST 04

Discharge density: 0.5 L min^{-1} m^{-2}

- ✓ obstructed and non obstructed fires;
- ✓ ventilation was considered;
- ✓ pre-burn time: 150 s;
- ✓ 0.13 m^3 of cellulose powder dispersed on different surfaces.



EXPERIMENTAL RESULTS

	Q [L min^{-1} m^{-2}]	Obstructed fire	Ventilation	Fire suppression	Fire extinction	Temperature control
Test 01	0,5	Yes	No	Yes	No	Yes
Test 02	0,9	Yes	No	Yes	No	Yes
Test 03	0,9	No	No	Yes	Yes	Yes
Test 04	0,5	Both	Yes	Yes	Yes	Yes

Main design parameter:

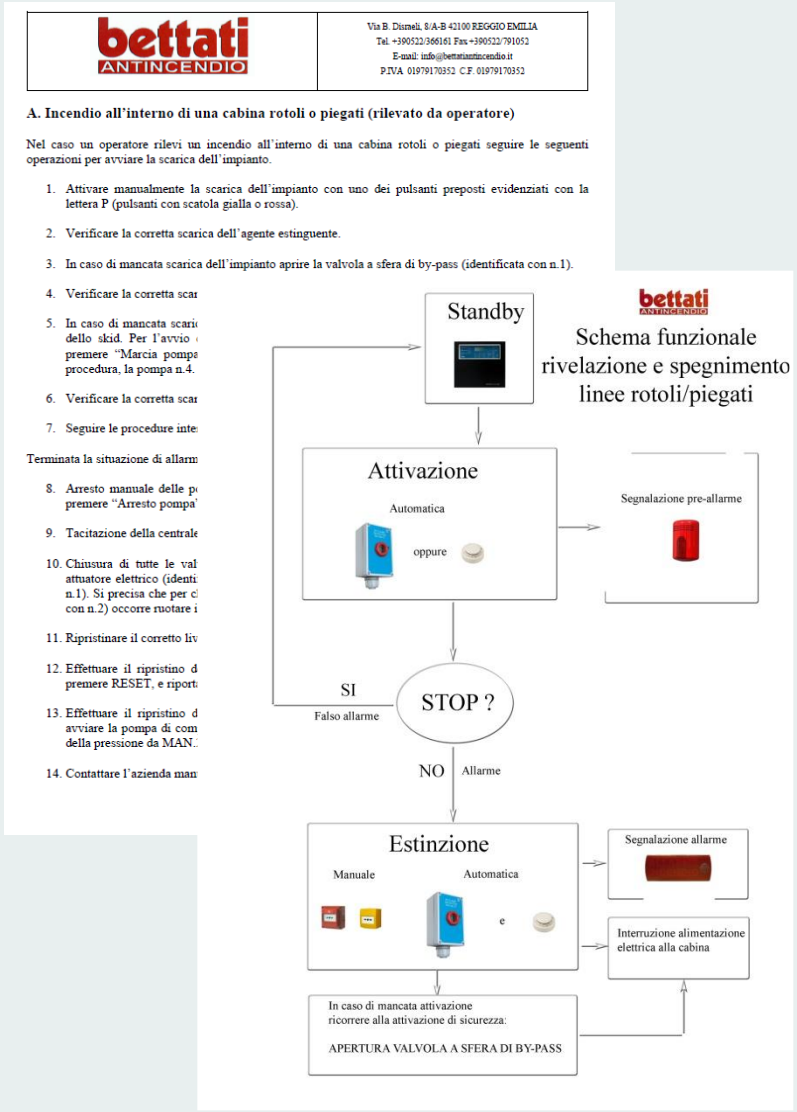
- ✓ DISCHARGE DENSITY = 1.4 L min^{-1} m^{-2} (50% safety factor);

Applicable to:

- ✓ total-compartment applications;
- ✓ systems integrated with an early-detection system (e.g.: flame detector).

The results obtained throughout the experimental campaign have been discussed and analyzed together with fire-safety and insurance consultants.

SYSTEM CUSTOMIZATION



bettati ANTINCENDIO

Via B. Disraeli, 8/A-B 42100 REGGIO EMILIA
Tel. +390522/366161 Fax +390522/791052
E-mail: info@bettatiantincendio.it
P.IVA 01979170352 C.F. 01979170352

A. Incendio all'interno di una cabina rotoli o piegati (rilevato da operatore)

Nel caso un operatore rilevi un incendio all'interno di una cabina rotoli o piegati seguire le seguenti operazioni per avviare la scarica dell'impianto.

1. Attivare manualmente la scarica dell'impianto con uno dei pulsanti preposti evidenziati con la lettera P (pulsanti con scatola gialla o rossa).
2. Verificare la corretta scarica dell'agente estinguente.
3. In caso di mancata scarica dell'impianto aprire la valvola a sfera di by-pass (identificata con n.1).
4. Verificare la corretta scar
5. In caso di mancata scari dello skid. Per l'avvio premere "Marcia pompa procedura, la pompa n.4.
6. Verificare la corretta scar
7. Seguire le procedure inte

Terminata la situazione di allarm

8. Arresto manuale delle p premere "Arresto pompa"
9. Tacitazione della centrale
10. Chiusura di tutte le val attuatore elettrico (identi n.1). Si precisa che per c con n.2) occorre ruotare i
11. Ripristinare il corretto liv
12. Effettuare il ripristino d premere RESET, e riport
13. Effettuare il ripristino d avviare la pompa di com della pressione da MAN.
14. Contattare l'azienda man

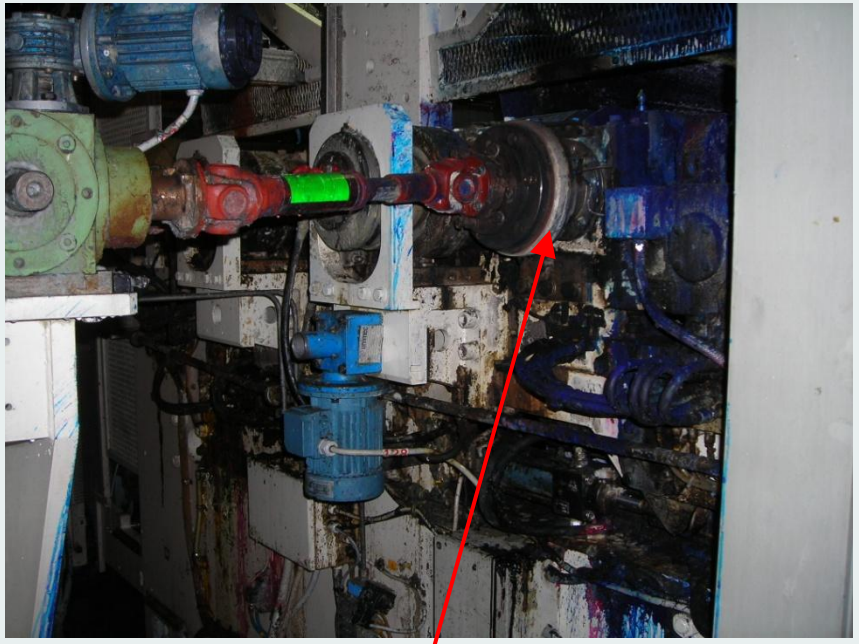
The water-mist system has been inserted in the whole safety program through a discussion with fire-safety consultants. Most notably, the following tasks have been accomplished:

- IMPLEMENTATION OF THE WATER-MIST SYSTEM WITHIN THE PROCEDURES OF THE SAFETY PROGRAM;
- INSTRUCTION OF THE INVOLVED PERSONNEL TO OPERATE THE SYSTEM (EVEN MANUALLY).

FIRE EVENTS -1-

Case 1

- **Date:** 4th October 2009;
- **Location:** Italy;
- **Ignition point:** Broken clutch (print group);
- **Fatalities:** None;
- **Damages:** Limited to some electric wires and plastic air ducts;
- **Water-mist action:** Extinction;
- **Business interruption:** 40 h (24 h to cleaning and re-establishment, 16 h to re-arrange full-load production).



Ignition point: broken clutch of the print unit

FIRE EVENTS -2-

Case 2

- **Date:** 30th October 2009;
- **Location:** Italy;
- **Ignition point:** Embosser;
- **Fatalities:** None;
- **Damages:** None due to the fire event;
- **Water-mist action:** Extinction;
- **Business interruption:** 6 h

Case 3

- **Date:** April 2010;
- **Location:** France;
- **Ignition point:** Embosser (brake pad);
- **Fatalities:** None;
- **Damages:** Plastic air ducts, sound-insulation materials in the work station;
- **Water-mist action:** Suppression;
- **Business interruption:** 18 h

FIRE EVENTS -3-

Case 4

- **Date:** 17th September 2010;
- **Location:** Italy;
- **Ignition point:** Bearing;
- **Fatalities:** None;
- **Damages:** None due to fire;
- **Water-mist action:** Extinction;
- **Business interruption:** 6 h

Fire-detection control-panel report

17-09-2010 ore 21,15

008 - Allarme CP riv. fiamma 21.15
009 - Dif. Terra
010 - Preal. Riv. Termico
011 - Allarme Termico
012 - Estinzione 21.15
013 - F. difet. Ter. 21.23
014 - Riarmo

CONCLUSIONS

- The system has shown remarkable effectiveness according to both the safety and the economic aspects;
- No fatalities have occurred over the fire events;
- Very limited damages resulted against the involved machineries;
- No fire spread was detected outside the involved work station;
- Very limited business interruption was borne by the production activity.

The *Gruppo SOFIDEL S.p.A.* (Porcari, Lucca, Italy) is gratefully acknowledged.

Thanks for your kind attention.

Questions?

Dr. Paolo E. Santangelo
Dipartimento di Ingegneria Meccanica e Civile
Università degli Studi di Modena e Reggio Emilia
Via Vignolese 905/b
41125 Modena (Italy)
Tel.: +39 059 205 6313
Fax: +39 059 205 6126
E-mail: paoloemilio.santangelo@unimore.it

Dr. Luca Tarozzi
Bettati Antincendio S.r.l.
Via B. Disraeli 8
42124 Reggio Emilia (Italy)
Tel.: +39 0522 369728
Fax: +39 0522 791052
E-mail: tarozzi@bettatiantincendio.it