Paper 14

Transit Packaging Conference

Pira's experience of remote testing

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The challenge of the 90s

Safe delivery of the product to the customer, on time, in prime condition, at minimum cost and with least environmental impact

Definitions

Safe delivery	-	Delivery not causing harm to the product, employees, distributor, retailer or customer
On time	-	Meeting delivery dates without recourse for recall
Prime condition	-	First class, original condition, without damage or spoilage to product or sales packaging
Minimum cost	-	That which, when all factors are considered, results in lowest total costs
Least environmental impact	-	That which results on balance in minimum usage of raw materials and energy and lowest emissions during manufacture and disposal

The challenge can only be met head on with sufficient information regarding the rigours of distribution. The information supplied by remote recorders or data loggers such as the EDR-3 allows the technologist to select optimum grades of materials and designs using minimum amounts of packaging able to withstand these rigours.

The EDR-3 provides information regarding spoilage and breakage mechanisms such as vibration, shock, temperature and humidity and identify where, when and how damage is occurring. Definition and quantification of those hazards encountered within any given distribution system allows a fully equipped and professionally staffed distribution packaging laboratory to reproduce these mechanisms and hazards, and packaging consultants to establish product or packaging development solutions in a fully cost effective manner.

Remote recording of distribution hazards

Uses

- To provide essential packaging design information
- To define and quantify the hazards encountered within a given distribution system
- To develop a corporate test schedule which accurately reflects its distribution system
- To develop performance specifications which reflect real rather than perceived performance
- To assist with packaging strategy, cost-reduction and rationalisation projects
- To identify and if possible eliminate the extremity of hazards within a given distribution system
- To reduce distribution damage through appropriate packaging

Potential benefits

- Provision of a reliable bench mark against which to measure the effectiveness of packaging designs, re-designs and new materials
- Reduced packaging and transportation costs through optimum design and specification
- Reduced damage rates through appropriate packaging design or elimination of hazard extremes
- Effective way to match packaging to the distribution system, and the increased scope for relevant tests to be incorporated into suppliers Quality Assurance systems
- Reduced management time in the control and development of packaging specifications through a performance related strategy
- Increased confidence that new packaging designs will perform

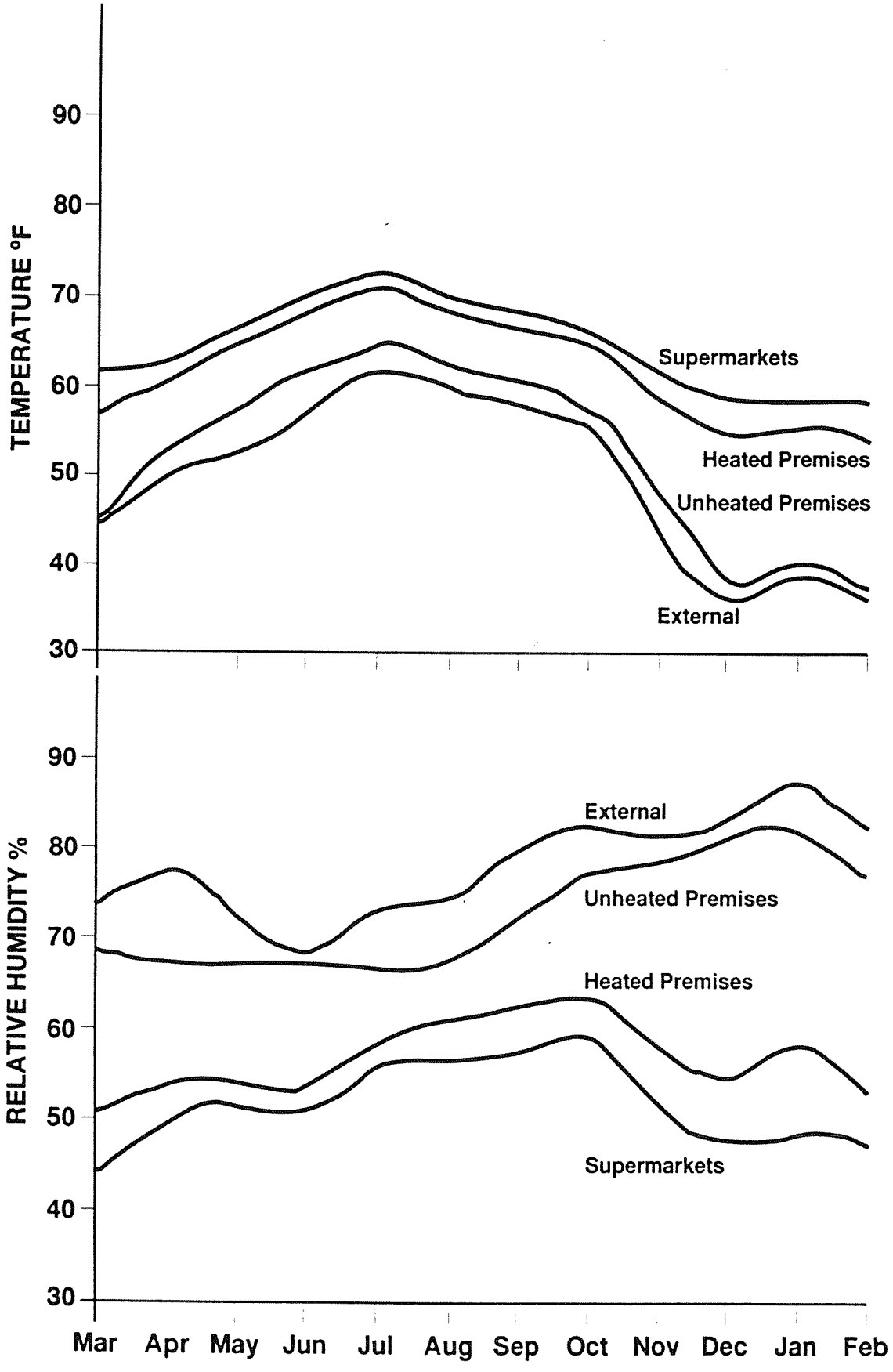
Examples of Pira history of remote recording of distribution hazards
Definition and quantifications of the hazards of distribution and storage has been the subject of Pira research and consultancy projects for 50 years. Specific examples:

1965 and 1971
Pira's collaborative projects with BFMIRA (Leatherhead Food Research Association) to survey temperature and humidity conditions in retail and wholesale premises remain definitive works.

The 1971 report presents the results of a 12 month survey of temperature and humidity conditions in retail and wholesale premises. Statistics graphs and tables are given for monthly means, maximum, minimum and average daily ranges in supermarkets, heated and unheated premises, covering six geographical areas in the UK. Such information is of fundamental importance if proper consideration is to be given to the design and use of suitable packaging for food.

Mechanical thermo-hydrographs manufactured by C F Cassella and Co Ltd or Negretti and Zambra Ltd calibrated against a wet and dry bulb psychrometer were used.

Comparison of Mean Temperatures and Mean Relative Humidities in Different Groups



1956 to 1962

Pira commissioned to assess drop hazards by rail and road over representative routes countrywide using the PATRA (Pira) drop recorder.

Six reports describe the drop hazard encountered by packages transported by road or rail in a parcels and mixed goods distribution system including an investigation of the effect of 'This Side Up' and 'With Care' labels. The effect of handholds was also investigated.

Example summary of drops recorded

Route: Leatherhead/Southampton/St Austell/Birmingham - Round trip

Containers - not specially labelled

Height in inches	6	12	24	Total
1 top	11	3	-	14
2 front	34	7	-	41
4 back	30	5	1	36
3 bottom	187	39	2	228
6 ins	262			
12 ins		54		
24 ins			3	
Total				**319**

Containers labelled "This side up" - "With care"

Height in inches	6	12	24	Total
1 top	5	6	-	11
2 front	25	2	-	27
4 back	14	1	-	15
3 bottom	171	47	1	219
6 ins	215			
12 ins		56		
24 ins			1	
Total				**272**

Route: Leatherhead/South London/Edinburgh/Bristol/North London/Leatherhead - Round Trip

Without handholds

Height in inches	6	12	18	24	Total
1 top	16	2	4	3	25
3 bottom	424	131	32	25	612
5 Right	19	1	1	1	22
6 Left	19	7	1	-	27
2 front	45	13	4	-	62
4 back	32	14	3	1	50
6 ins	555				
12 ins		168			
18 ins			45		
24 ins				30	
Total					**798**

With handholds

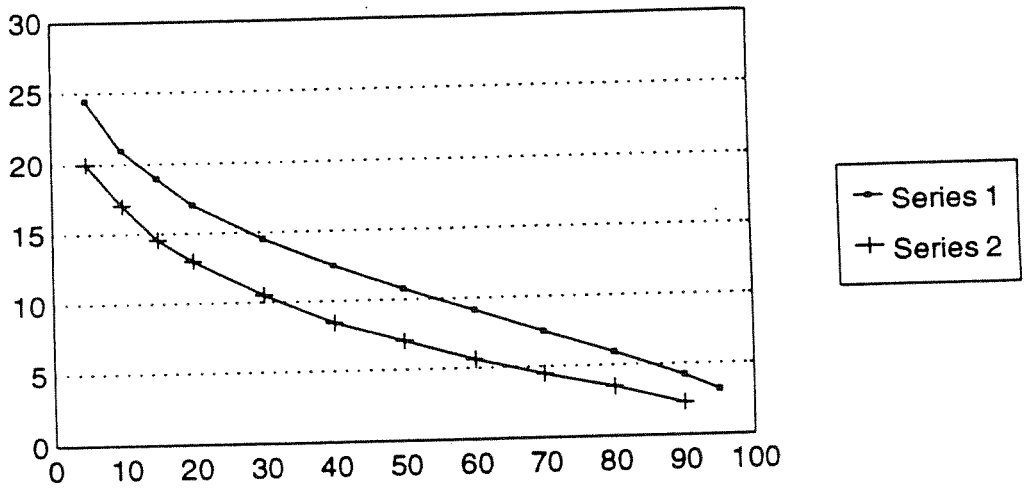
Height in inches	6	12	18	24	Total
1 top	12	2	-	-	14
3 bottom	418	88	35	12	553
5 Right	12	3	1	-	16
6 Left	18	3	-	-	21
2 front	17	8	-	-	25
4 back	24	10	-	-	34
6 ins	501				
12 ins		114			
18 ins			36		
24 ins				12	
Total					**663**

1960s

Various observational studies of the handling of paper sacks. Manual and mechanical handling systems were studied for sacks of 56 and 112 lbs in chemical industries and for animal foodstuff. The drop hazard was quantified.

Unloading lorries Flat drops only

1: 112 lb sacks, open stack 10 high
2: 56 lb sacks, open stack 15 high



Drop height inches
% drops at or above height indicated

1969 - Investigation of package handling in air transportation
The study recorded drops received by packages sent by air in the freight holds of passenger carrying aircraft.

Package weights of 30 lbs and 75 lbs were investigated

Journeys included London to New York, London to Hong Kong and London to Sydney.

Trial AT-9 Distribution of drops over faces of 22 lb package
Expressed as a percentage of all drops over 3" (7.5 cm)

	%
Top	17
Front	3
Base	28
Back	22
Left end	17
Right end	15
Total drops	**58**

Trial AT-9 Drops recorded analysed by airport
22 lb package

Airport	no of handlings n	Total drops recorded in. (cm) 3" 7.5	6" 15	9" 22	12" 31	15" 38	18" 46	24" 61	30 76	36" 91	Total
London	4	11	4	1	2	1	1		1	1	22
Amsterdam	8	12	6	1	3		2				24
Frankfurt	4	9	2			1					12

Drops received by individual 30 lb packages at London airport

Table gives the percentage having at least 0, 1, 2 drops over the indicated heights per airport handling

No of drops	Over 3" 7.5	Over 6" 15	Over 12" 31	Over 18" 46	Over 24" 61	Over 30" 76	Over 36" 91 cm
0	100	100	100	100	100	100	100
1	100	94	63	40	20	9	
2	97	86	48	11	3		
3	86	77	26				
4	77	54	11				
5	69	37	9				
6	43	23					
7	37	9					
8	34	6					
9	20	3					
10	14						
11	11						
12	6						
13	3						
14	3						
15	3						

No of airport handlings = 35

Drops received by individual 75 lb packages at London airport

Table gives the percentage having at least 0, 1, 2 drops over the indicated heights per airport handling

No of drops	Over 3" 7.5	Over 6" 15	Over 12" 31	Over 18" 46	Over 24" 61	Over 30" 76	Over 36" 91 cm
0	100	100	100	100	100	100	100
1	97	89	43	11	3	3	3
2	82	63	14				
3	77	40					
4	57						
5	34						
6	20						
7	6						
8	3						
9	3						

No of airport handlings = 35

1987 - 89 Application of random vibration testing to package and product development

Objective

To make lab testing using random vibration a feasible proposition in preference to transit trials.

Vibration measurements were recorded in the field using accelerometers, signal conditioning and magnetic tape in 2 1/2 ton and 5 ton box vans, 32 1/2 ton curtain sided articulated lorry, 2 1/2 ton fork truck and rail freight wagons.

Product areas investigated:

Canned foods	-	Label scuffing
Electronic Products	-	Metal fatigue, cracking in circuit boards, cover abrasion, detachment of components etc
Building materials	-	Scuffing and chipping of bricks and tiles
Glass bottles	-	Surface abrasion
Fine art, paintings	-	Paint flaking, chipping and cracking

1991

Pira purchases EDR-3 programmable Electronic Data Recorder for the remote measurement of vibration, shock, temperature and humidity.

Pira commissioned on consultancy basis to evaluate distribution and storage hazards.

Three examples:

- On line hazards experienced by cased spirits
- Monitoring of shock, temperature and humidity associated by packaged palletised electronic product during an air flight from London to Japan
- Monitoring of palletised food product for vibration, temperature and humidity during road transport from North West England to Portsmouth.

Case studies

1 Monitoring of on-line hazards experienced by cased spirits

Background

Damage experienced on-line, in particular bottle breakage. Consequent product leakage and case wettage, result in reduced line efficiency and profitability

Objective

To assess and quantify the hazards experienced by cased bottles of spirits on-line, that is case packer to palletiser, a journey of approximately one half miles, using remote electronic data recording equipment.

To identify any hazard 'hot spots', that is those areas on-line which subject the cases and bottles to the greatest hazard levels.

To provide quantified hazard data to allow accurate laboratory simulation of line hazards and thus aid future pack design and development.

Procedure

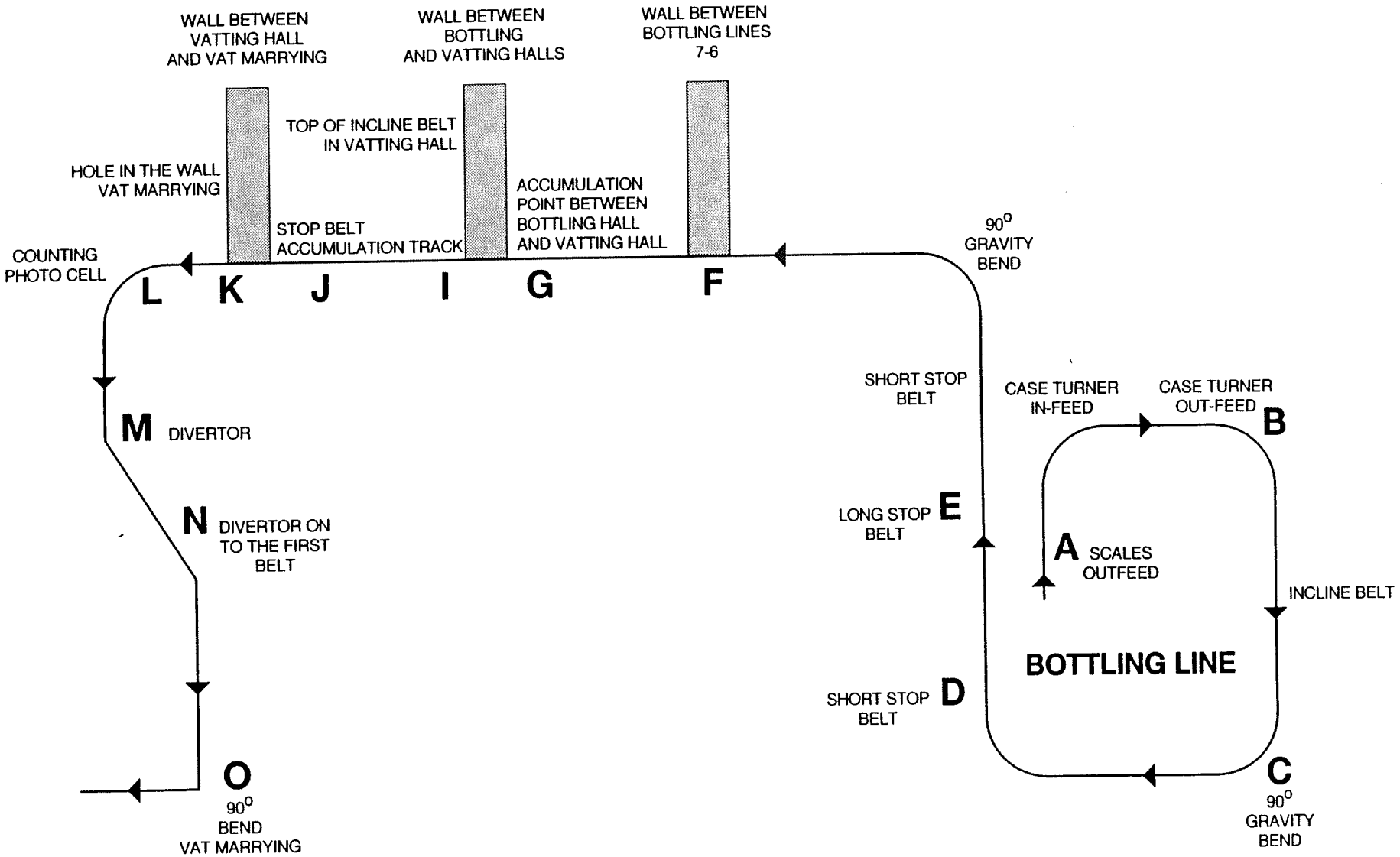
Five different lines were monitored. Each line was followed and mapped from case packer through to palletisation. A number of points were identified alphabetically to provide reference points for accurate location of cases at any given time, allowing cross referencing with recorded shock data.

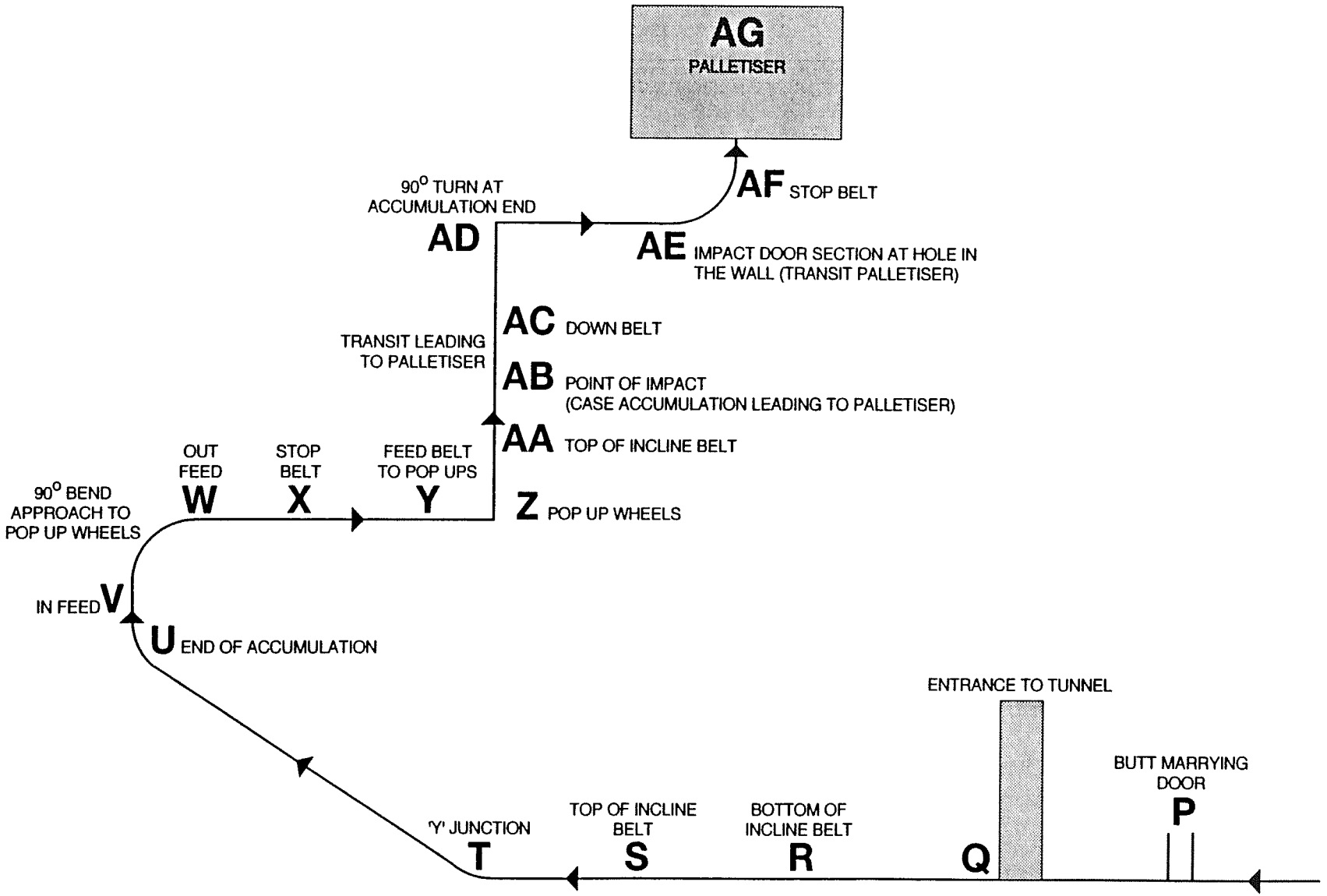
The EDR was located within the case and each line monitored.

Only shock events in excess of 5 g and 5 ms were recorded.

Results

Line location	Event No	Shock Level	Pulse duration	Direction
4" drop to start	1	23g	20ms	base - top
A - case turner in feed	2	10g 8g	10ms 10ms	front - back base - top
D - short stop belt	3	8g	10ms	front - back
F - wall between bottling lines 7 & 6	4 5	8g 8g	12ms 15ms	front - pack back - front
J - stop belt accumlating track	6	9g	10ms	front - back
AA - top of incline belt	7	15g	7ms	back - front
AE - impact section at hole in wall to palletiser	8	18g	8ms	back - front


WALL BETWEEN VATTING HALL AND VAT MARRYING
WALL BETWEEN BOTTLING AND VATTING HALLS
WALL BETWEEN BOTTLING LINES 7-6
TOP OF INCLINE BELT IN VATTING HALL
HOLE IN THE WALL VAT MARRYING
STOP BELT ACCUMULATION TRACK
ACCUMULATION POINT BETWEEN BOTTLING HALL AND VATTING HALL
90° GRAVITY BEND
COUNTING PHOTO CELL
L
K
J
I
G
F
M DIVERTOR
N DIVERTOR ON TO THE FIRST BELT
O 90° BEND VAT MARRYING
SHORT STOP BELT
CASE TURNER IN-FEED
CASE TURNER OUT-FEED
B
LONG STOP E BELT
A SCALES OUTFEED
INCLINE BELT
BOTTLING LINE
SHORT STOP D BELT
C 90° GRAVITY BEND


AG
PALLETISER
AF STOP BELT
90° TURN AT
ACCUMULATION END
AD
AE IMPACT DOOR SECTION AT HOLE IN
THE WALL (TRANSIT PALLETISER)
TRANSIT LEADING
TO PALLETISER
AC DOWN BELT
AB POINT OF IMPACT
(CASE ACCUMULATION LEADING TO PALLETISER)
AA TOP OF INCLINE BELT
OUT
FEED
W
STOP
BELT
X
FEED BELT
TO POP UPS
Y
Z POP UP WHEELS
90° BEND
APPROACH TO
POP UP WHEELS
IN FEED V
U END OF ACCUMULATION
ENTRANCE TO TUNNEL
BUTT MARRYING
DOOR
P
'Y' JUNCTION
T
TOP OF INCLINE
BELT
S
BOTTOM OF
INCLINE BELT
R
Q

2 Monitoring of shock, temperature and humidity associated by packaged, palletised electronic equipment during an air flight from London to Japan

Background

Japan and air freight were new markets and new transportation systems for an existing product.

Objective

To survey shock, temperature and humidity hazards encountered by packaged product X in transit by road and air from London to Japan.

Procedure

The EDR-3 was rigidly affixed to the machine which was located in cushioning within a pack in the bottom layer of a pallet box.

The EDR was set to record shock events in excess of 2.5 g and to record temperature and humidity at 30 minute intervals.

The pallet box was despatched to Heathrow airport by road and then by air to Japan.

Results

EDR: Shock Frame Report

Peak levels - Gs

Contains 10 Acceleration Frames

Date	Time	x +/-	y +/-	z +/-
04/06	16:06:16	1.0	3.9	0.8
05/06	19:03:02	0.7	3.0	0.8
08/06	06:19:49	1.3	1.0	3.4
08/06	06:21:05	1.3	1.0	3.7
08/06	06:21:26	2.4	1.3	4.1
08/06	06:36:43	0.4	0.7	3.4
08/06	07:08:59	2.1	4.2	0.8
09/06	15:11:19	1.8	1.6	3.8
09/06	15:11:40	1.5	1.0	3.8
12/06	07:37:48	0.7	3.6	0.8

EDR: Statistical summary report
Acceleration statistics

		x	y	z
Peak Accel Levels	max	2.38	4.16	4.07
	min	0.42	0.43	0.49
	mean	1.21	1.61	2.48
	std-dev	0.66	1.39	1.50

EDR: Statistical summary report
Climatic statistics

	Temperature	% relative humidity
max	26.67	70.00
min	17.22	51.00
mean	22.57	64.69
std-dev	2.39	2.35

3 Monitoring of palletised food product for vibration temperature and humidity during road transport from North West England to Portsmouth

Background

Loads shift of product results in loss of vehicle and warehouse efficiency and compromises stacking strength.

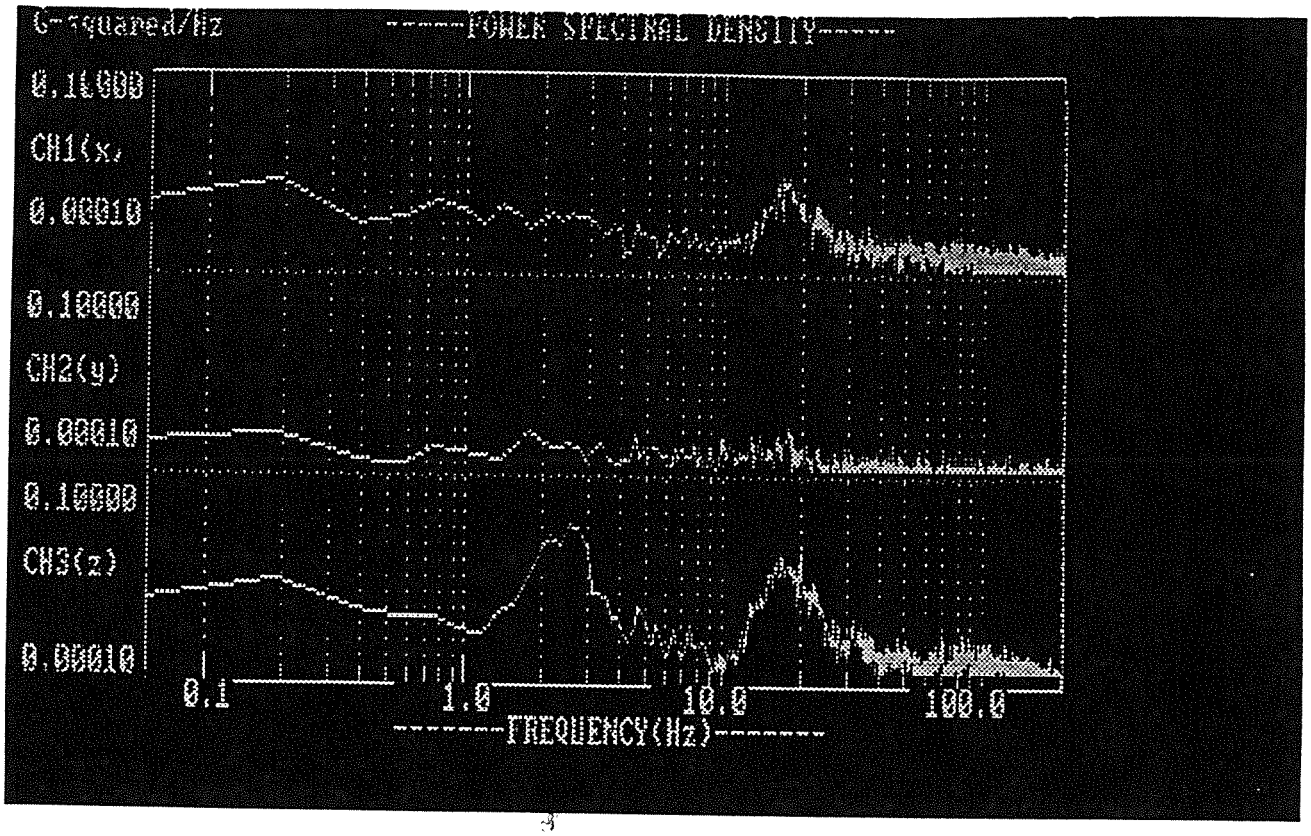
Objective

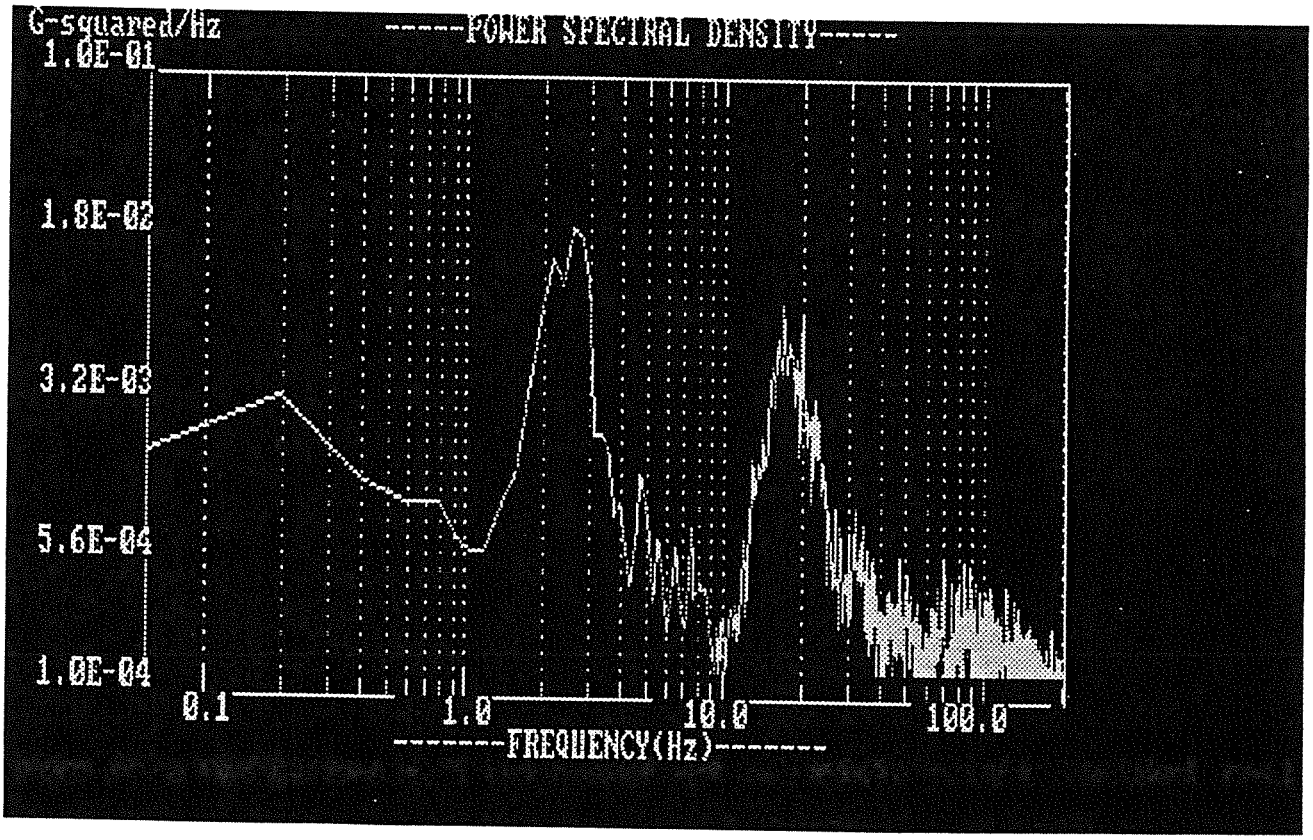
To quantify the vibration and climatic hazards associated with a road journey from N.W. England to Portsmouth and use this data for vibration testing and formulation of a corporate vibration test schedule for use in future trials.

Procedure

Recordings were taken from fully loaded air cushioned suspension 40 ft trailers. The EDR-3 was set to monitor input acceleration, and was hard mounted to the pallet. All three directions were monitored.

The severest vibration events were recorded and a power spectral density (power shown against frequency) generated.


G-squared/Hz
-----POWER SPECTRAL DENSITY-----
0.10000
CH1(x)
0.00010
0.10000
CH2(y)
0.00010
0.10000
CH3(z)
0.00010
0.1
1.0
10.0
100.0
-------FREQUENCY(Hz)-------


G-squared/Hz
-----POWER SPECTRAL DENSITY-----
1.0E-01
1.8E-02
3.2E-03
5.6E-04
1.0E-04
0.1
1.0
10.0
100.0
-------FREQUENCY(Hz)-------

Conclusion

Remote recording and scrutiny of the distribution environment has proved an invaluable aid to the laboratory simulation of hazards of transportation and storage for fifty years at Pira.

The work continues and provides our members and clients with the bespoke information required to formulate optimum product and packaging design in the most cost and time effective manner.

The benefits of accurate definition of the transit environment are clear: increased profitability, least environmental impact and above all **customer satisfaction**.