"FIBEROPTIC VARIABLE MESSAGE SIGNS"

Ladd Canyon - Drinking Fountain Grade Section Old Oregon Trail Highway (Interstate 84)

Final Report

Experimental Features Project OR 91-01

by

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prepared for

OREGON DEPARTMENT OF TRANSPORTATION
Salem, Oregon 97310

and

FEDERAL HIGHWAY ADMINISTRATION
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Technical Report Documentation Page

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16. Abstract

The SYLVIA® fiberoptic variable message signs (VMS) were installed on the Old Oregon Trail Highway (I-84) at milepost 263.4 near La Grande and at milepost 286.7 near North Powder. The purpose of the signs is to warn motorists of fog, winter blizzard conditions and high wind conditions.

The evaluation of the SYLVIA® fiberoptic VMS was conducted by the Oregon Department of Transportation staff as part of an Experimental Features Program research project. The issues of reliability and ease of operation were investigated. These signs have functioned well, overall. Legibility of the signs are excellent in the conditions evaluated, the maintenance requirements have been minor, the cost of operation has been reasonable, and driver compliance has been excellent. An additional benefit is that the length of time required to close the highway is significantly lower, since the signs aid maintenance personnel with informing drivers of the closure.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

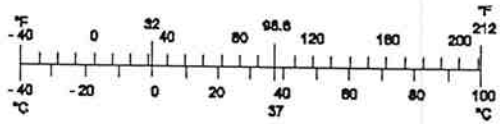
Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meres cubed	m^3

NOTE: Volumes greater than 1000 L shall be shown in m^3.

		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8 + 32	Fahrenheit	°F



* SI is the symbol for the International System of Measurement

(4-7-94 jbp)

ACKNOWLEDGEMENTS

The author wishes to thank James Rusnak, Eric Brooks, Terry Helman, District 13 Office Manager and Region 5 Traffic Operations personnel for their active role in providing information used in this report. The author would also like to thank Liz Hunt, Dan Sosnovske, and Keith Martin for reviewing this report.

DISCLAIMER

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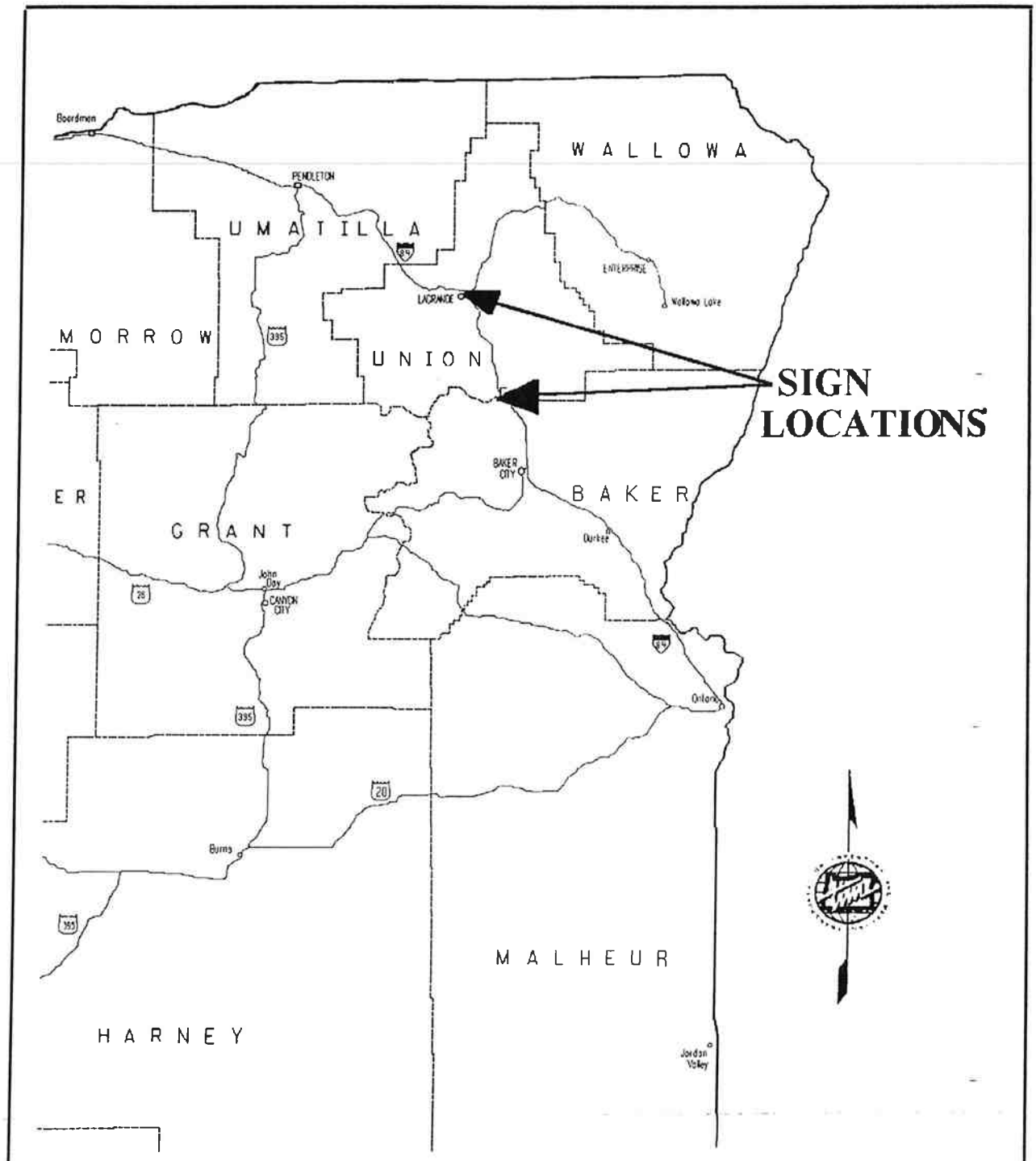
1.0 INTRODUCTION

One viable way of providing real-time information to motorists is with variable message signs (VMS). One type of VMS utilizes fiber optics to control the bulbs and shutters. Fiberoptic VMS were installed on the Old Oregon Trail Highway at mileposts 263.4 near La Grande and 286.7 near North Powder (see Figure 1.1). The purpose of the signs is to warn motorists of fog, winter blizzard conditions and high wind conditions. Photographs of the sign installation are included in Appendix A. The VMS allows the maintenance staff to control the signs from the office, saving travel time and allowing immediate warning message display.

The fiberoptic message signs installed are the SYLVIA® Model 420 system manufactured by Fiberoptic Display Systems (FDS). The system components include the sign, controller box, and sign control software. These signs feature provisions for lowering and increasing light intensities to compensate for the wide range of environmental lighting conditions. The sign's display characters contain 35 electrically controlled shutters in a 5"x7" [127mm x 178mm] dot matrix format. Each shutter receives the end of two fiberoptic light guides. The shutter is controlled by a short current pulse enabling free passage or masking of the light flow. The controller box is a software-oriented microprocessor with resident software installed in a non-volatile memory. The controller is capable of providing a serial interface with the central computer, controling and monitoring the sign, and sending status reports to the central computer. The software communicates with the signs through a computer and modem. Complete specifications of the components are included in Appendix B.

The visibility of fiberoptic units appear to be better than bulb matrix units. A demonstration conducted in September 1989 in Pendleton, Oregon, compared an existing 26" [660 mm] letter height bulb-matrix sign to a FDS' SYLVIA® Model 420 sign with an 18" [460 mm] letter height. Most observers were impressed by the legibility of the SYLVIA® unit, legible at 1200+ feet [370 m] while the bulb-matrix sign did not become legible until 1000 feet [300 m].

The evaluation of the fiberoptic VMS was conducted by ODOT staff as part of an Experimental Features Program research project. The research project was designed to evaluate the ease of operation, reliability, maintenance requirements, visibility, driver compliance and the operating costs of the SYLVIA® Model 420 system. The information obtained from the study, will assist ODOT's traffic engineering staff in comparing the SYLVIA® sign to other VMS.



Vicinity Map

RESEARCH UNIT
OREGON DEPARTMENT OF TRANSPORTATION

FIGURE 1.1

2.0 EVALUATION

2.1 EASE OF OPERATION AND RELIABILITY

Ease of operation is a function of the software capabilities, which provides a menu to allow the user to select options. After an option is selected, the computer transmits the message through a modem to the controller box. The easy to use software is designed to run on a dedicated computer, that should run continuously. The software runs in a DOS environment which does not easily allow the use of multiple applications. If the software was used in a Windows® environment, the computer would be available for other applications.

Access to sign status data is a concern for the users. The only way to verify the sign status after programming a sequence is to display the status table. Because the status table will not indicate that the signs are on until the sequence begins, if a delayed start is part of the programmed sequence, problems can occur. Problems vary from communication failures involving the modem to the sign failing to turn on. Tracking a series of communication failures is practically impossible. Although the software provides a log file of all transactions, the causes of communication failures are not identified.

The reliability of the signs was questioned when communication between the system computer and the SYLVIA® sign at North Powder failed on several occasions. After installing a modem reset interface at the sign, the failures ceased.

2.2 MAINTENANCE

Minor maintenance has been required for the two signs. The thermostats have been replaced in both signs. The sign at La Grande has had one shutter replaced. The North Powder sign has had four shutters replaced. A detailed maintenance log is included in Appendix C.

One lamp between the two signs has been replaced in three years of operation. The lamp and separate reflector system has been changed in the vendor's new signs to an integrated bulb and reflector. The new system provides greater lamp intensity, more precisely focuses the light from the lamps and increases the life of the bulb. The vendor does have a modification kit that is available to update the lamps in the current signs.

2.3 VISIBILITY AT M.P. 263.4 (La Grande)

Sign visibility monitored at the M.P. 263.4 VMS has been good under both day and night conditions. During the day, the sign system provides an overbright option, and at night a dimming option to reduce light bleeding can be used. At this particular installation, the overbright and dimming feature has provided favorable results. In general, the sign becomes

legible at approximately 1000 ft [300 m]. Table 2.1 provides specific information obtained from field evaluations under various weather conditions.

TABLE 2.1 FIELD OBSERVATIONS

Fiberoptic Variable Message Signs
I-84 @ MP 263.4
Visibility Evaluation

DATE	TIME	OBSERVER	WEATHER CONDITIONS	TEMP	MESSAGE	LEGIBILITY DISTANCE
11/30/92	1000	R.Alexander	Light Snow	28°F (-2°C)	Single Axle Trucks Pulling Trailers Chains Required/ All Other Vehicles Traction Tires Or Devices Required	1300' (400 m)
12/8/92	900	L.Warburton	Moderate Snow	28°F (-2°C)	Ladd Canyon Closed To Mobile Homes Due To High Winds	1000' (300 m)
12/12/92	900	J.Miller	Cloudy	28°F (-2°C)	Traction Tires Or Devices Required	1000' (300 m)
12/15/92	700	M.Frederick	-	26°F (-3°C)	Traction Devices Required Chainup Area 5.5 Miles Ahead	900' (270 m)
12/19/92	1100	J.Miller	Light Snow	27°F (-3°C)	Ladd Canyon Blowing Snow- Poor Visibility Do Not Stop in Roadway	750' (230 m)
1/8/93	1500	R.Alexander	Snow	-	Traction Devices Required Chainup Area 5.5 Miles Ahead	-
1/11/93	715	M.Frederick	-	18°F (-8°C)	Carry Traction Tires Or Devices	900' (270 m)
1/13/93	900	L.Warburton	Moderate Snow	20°F (-7°C)	Ladd Canyon Blowing Snow- Poor Visibility Do Not Stop in Roadway	1000' (300 m)

2.4 DRIVER COMPLIANCE

According to District 13 Maintenance personnel, driver compliance has been excellent. When the sign has been used to notify drivers that the freeway is closed, parked trucks accumulate on the pavement shoulder, a definite indication of compliance.

2.5 COST OF OPERATION

Although, operating costs were the only costs evaluated, the original cost of each sign, including training, is shown below. The operating costs were supplied by District 13.

The new SYLVIA® signs include an integrated bulb and reflector. If more signs are purchased, it may be advantageous to upgrade the La Grande and North Powder signs to include the new bulb and reflector system. One type of bulb and reflector system for the State, would standardize the purchase of replacement parts and insure availability. The upgrade and replacement costs were supplied by FDS.

SYLVIA® Model 420 Signs	
Initial Costs (Includes Training)	$170,000/sign
Average Yearly Operating Costs	
Power	$525.00
Modem	$500.00
Phone	$450.00
TOTAL	$1475.00
Lamp Replacement Costs	
Lamp #64004 (2,000 hr)	$11.85
Lamp #64005 (6,000 hr)	$22.00

Two alternatives are available to upgrade the lamps to the integrated bulb and reflector system. Alternate 1 would include purchasing the modification kit and lamp separately. Alternate 2 would include purchasing the modification kit and two lamps as a kit. The cost comparison is shown below.

VMS Upgrade Costs:

Alternate 1:

Lamp modification kit: 36 x $8.00/lamp= $288.00
Lamp #64005 (6,000 hr): 36 x $22.00/lamp= $792.00
TOTAL $1,080.00/sign

Alternate 2*:

Lamp modification with two #64005 lamps: 36 x $50.25/lamp= $1,809.00/sign

*Alternate 2 would provide an extra set of lamps. The cost per lamp would be $20.25: ($1809-$1080)/36 lamps. The $20.25/lamp compares to $22.00/lamp if purchased separately.

3.0 CONCLUSIONS AND RECOMMENDATIONS

The SYLVIA® Model 420 variable message signs have functioned well. Legibility was excellent for the conditions evaluated, maintenance requirements have been minor, operation costs are reasonable and driver compliance is excellent. An additional benefit is that the length of time required to close the highway is significantly lower, since the signs aid maintenance personnel with informing drivers of the closure.

The SYLVIA® Model 420 is an acceptable VMS that should be considered for future applications by the ODOT traffic engineering staff. Modifications to the software, however, are recommended prior to future purchases. The software modifications recommended include:

1) The software should be updated to run in a Windows® environment.
2) Access to sign status information should be easily available.
3) Causes of failure should be identifiable.

In addition, after ODOT's current inventory of lamps has been depleted, we recommend the lamps be upgraded, as needed, with the vendor's modification kit.

Fiberoptic Display Systems' also has provided recommendations that are included in Appendix D.

APPENDIX A

Variable Message Sign at La Grande:

APPENDIX B

FIBEROPTIC DISPLAY SYSTEMS, INC.
1 Thurber Boulevard
Smithfield, RI 02917 U.S.A.
(401) 232-3370 FAX (401) 232-7130

An S.E.S. Company

Patent 4.794.391

SYLVIA technical leaflet

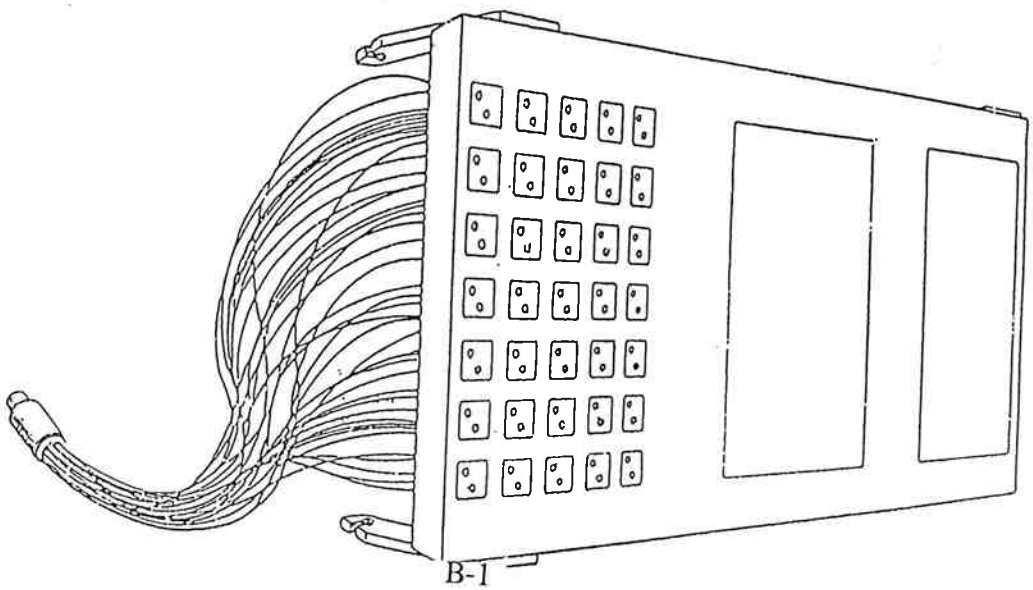
DISPLAY MODULES

SYLVIA display characters contain 35 electrically controlled shutters in a 5 X 7 dot matrix format. Each shutter receives the end of two fiberoptic light guides.
The shutter is controlled by a short current pulse enabling free passage or masking of the light flow. An inherent magnetic memory in each shutter retains the display indefinitely with no control power.

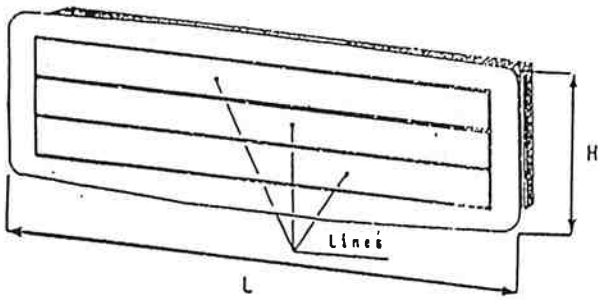
The 12.5 inch display characters (series 320) and 18-inch display characters (series 420) are ideal for changeable message signs (CMS) on roads and freeways, to provide the driving public with timely information about road conditions ahead.

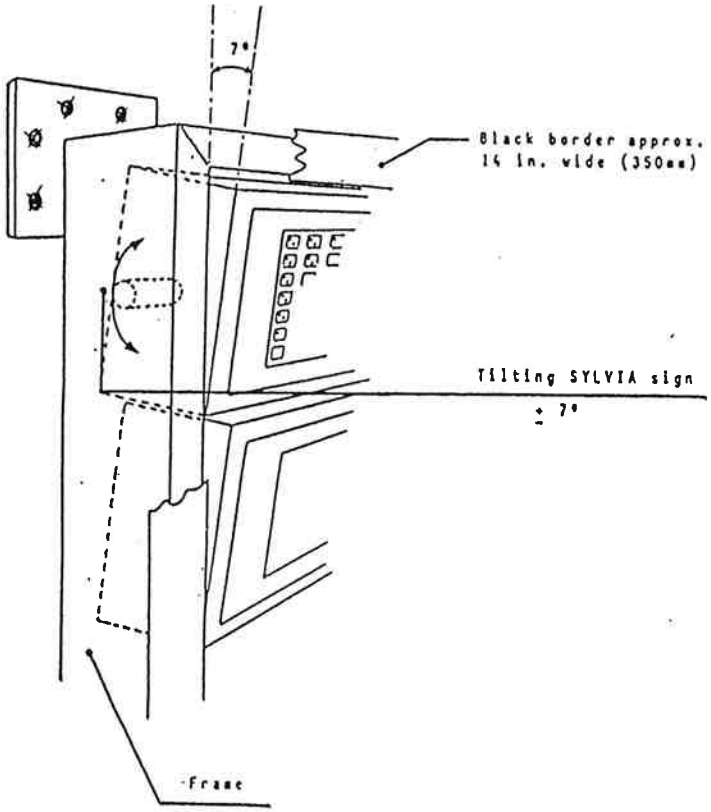
BENEFITS :

* Superior visibility and legibility under all weather conditions.
* Dimming of the light source to avoid any dazzle in low ambient light.
* Functional test or passage from a message to another without visual disturbance (lamps are turned off during the updating process).
* Writing speed better than 60 characters per second.
* Flashing messages, alternate messages.
* Low energy consumption.
* Proven performance and reliability with over 100 systems operational.



SYLVIA BOARD : GENERAL SPECIFICATIONS





The SYLVIA sign consists of a frame and of one to four lines of 12, 15 or 18 characters series 320 or series 420 (maximum 64 characters).

Frame :

Made of welded aluminum alloy, the frame allows :

- mounting and tilting of the lines,
- mounting of the SYLVIA sign to a support structure (sign bridge, cantilever or post),
- mounting of a maintenance catwalk behind the sign. (option)

A matte black border is mounted on the frame to enhance readability

Lines :

- Structure made of welded aluminum alloy,
- Housing envelope made of anodized aluminum ., bolted to the structure,
- Sign face made from 1/4 in. methacrylate with antiglare device . Modules are removable with no tools required.
- 3 Character modules, including fiberoptic system and lighting module,
- Rear access doors for service and inspection, equipped with gas struts. Front access is an available option.

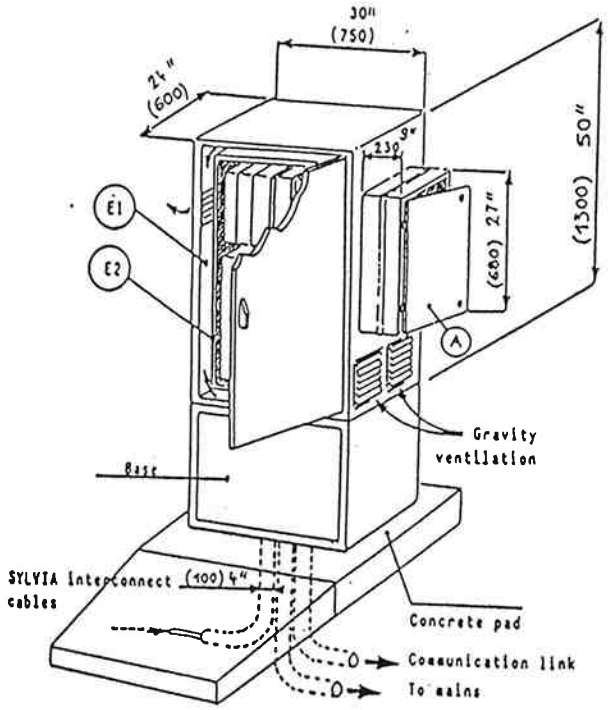
Each line (or group of lines) includes an adjustment device (+ - 7°) which allows optimal tilting of the sign with regard to the site configuration.
The sign has been designed to withstand wind pressures of 1600 Pa and to operate over an ambient temperature range of -25 to +45° C without heating or forced air cooling.
Thermostatically controlled heating of the sign face is a advisable option in cold climates to prevent fogging of the sign face.

DIMENSIONS (APPROX.)

SYLVIA	NUMBER OF LINES	12 CHARACTERS WEIGHT lbs.	L	H	WEIGHT catwalk	15 CHARACTERS WEIGHT lbs.	L	H	WEIGHT catwalk	18 CHARACTERS WEIGHT lbs.	L	H	WEIGHT catwalk
12.5" 320	1	1150	17'1"	5'7"	375	1350	20'8"	5'7"	440	1520	23'8"	5'7"	520
	2	1570	17'1"	7'8"	375	1870	20'8"	7'8"	440	2130	23'8"	7'8"	520
	3	2000	17'1"	9'8"	375	2370	20'8"	9'8"	440	2750	23'8"	8'8"	520
	4	2420	17'1"	11'5"	375	2880	20'6"	11'5"	440				
18" 420	1	1710	22'3"	8'4"	430	2010	28'10"	8'4"	570	2200	31'4"	8'4"	870
	2	2310	22'3"	8'4"	430	2730	28'10"	8'4"	570	3150	31'4"	8'4"	870
	3	2890	22'3"	10'10"	430	3455	28'10"	11'6"	570	3680	31'4"	11'6"	870
	4	3520	22'3"	13'7"	430	4200	23'10"	14'01"	570				

SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE

CONTROL CABINET



DIMENSIONS IN BRACKETS ( ) ARE IN MILLIMETERS

The maximum interconnect cables length is 100 ft (30 m).

Double-enclosure type (E1) (E2) insuring IEC 55 degree (Nema 3) of protection with lamps supply transformer.

SPECIFICATIONS :

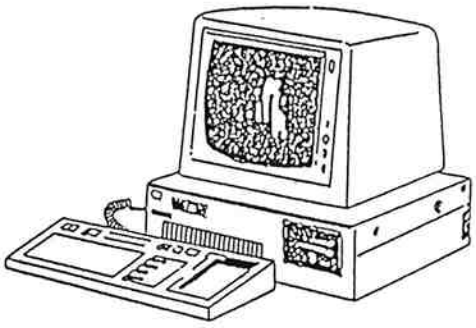
* 115 V ± 10% 60 Hz
  single phase
* Power consumption inside the control cabinet : 500W max.
  (not including sign lamps - see "Fiberoptic system" - and maintenance outlets).
* Weight 370 lb (170 kg) approx.
* Main power supply and distribution
* Sign lamps supply
* Controller
* Communication interface.
* Accessories (internal lighting, internal heating, maintenance outlets...)

The controller is software-oriented microprocessor type with resident software furnished and installed in non-volatile memory.

The controller is capable of providing :

* RS 232 C serial interface for communication with a Central Control Computer,
* Control and monitoring of the sign,
* Sending of status reports to the Central Control Computer.

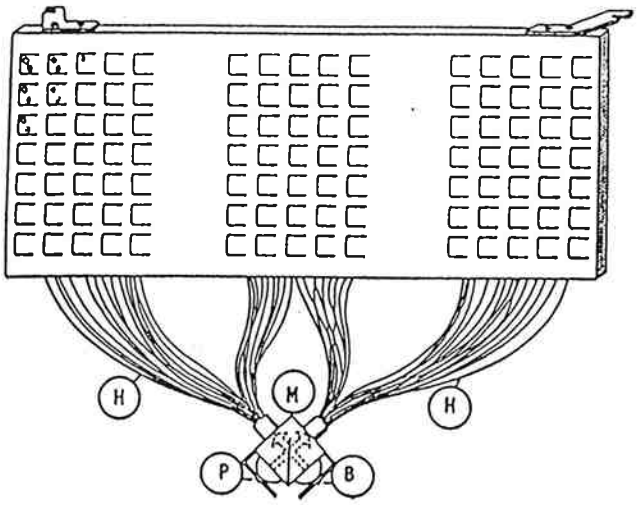
..... SYLVIA ..... CENTRAL CONTROL SYSTEM .....



The central computer system runs on any IBM or fully compatible personal computer under MS.DOS. The software has an user friendly interface and a context sensitive help and features :

* Control of up to 35 signs on private, leased, dial-up lines or via cellular phone.
* Storage of up to 12000 messages.
* Programmable sequences over a week.
* Operator log-in with password protection and individual access rights.
* Monthly log files.

FIBEROPTIC SYSTEM



One lighting module (M) feeds 2 fiberoptic harnesses (H)
Each one consisting of 105 glass fiber bundles protected by PVC jacketing;

Each lightguide end is fitted with a convergence cone.

The cone widens the dot and increases intensity axially.

Three display characters are operated using one lamp (P)
In the overbrightness mode both the primary and backup lamps are employed for added punch (sun directly into the sign face situation).

(H) = Fiberoptic harness (105 bundles)

(M) = Lighting module mounted on vibration absorbing platform

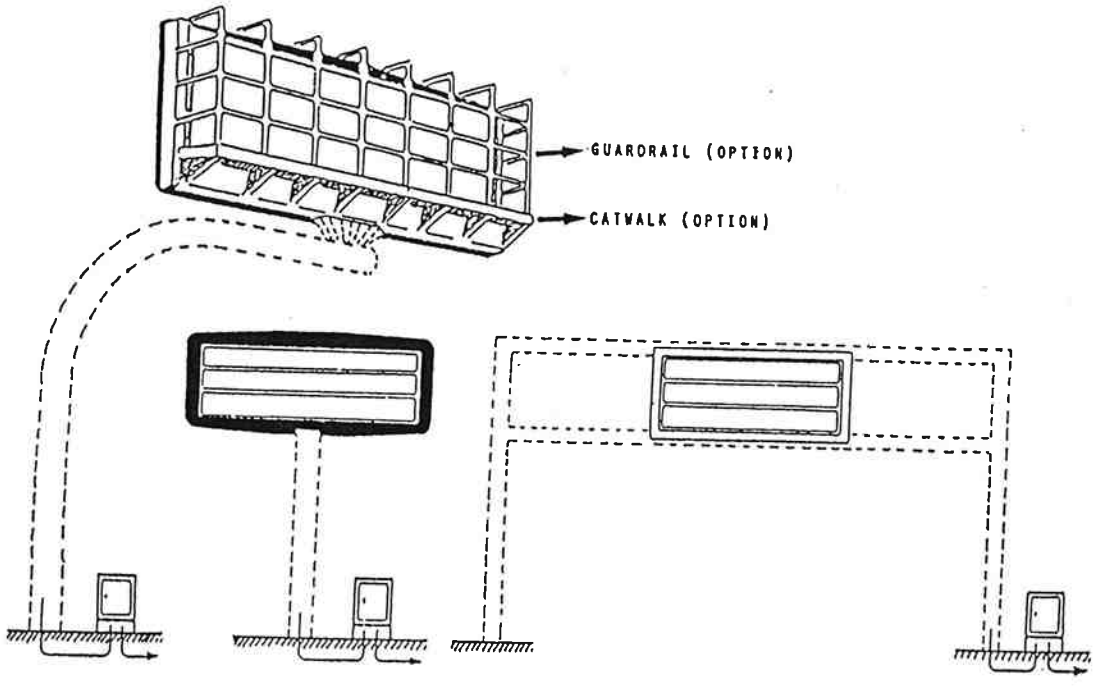
(P) (B) = Primary and back-up lamps 10V 50W (6000 hours)

POWER CONSUMPTION

OPERATING CONDITIONS	LAMPS VOLTAGE	1 LINE SYLVIA 320 OR 1 LINE 420		
		12 charact.	15 charact.	18 charct.
Day	10 V	250 W	315 W	375 W
Night	4.5 V	80 W	100 W	120 W
Overbright	10 V	500 W	630 W	750 W

NOTE : These figures do not include sign heating option.

..... SYLVIA ..... EXAMPLES OF INSTALLATIONS .....



Supports must be designed to enable access to the inspection doors located at the back of the housings, unless front opening is required.

APPENDIX C

SIGN HISTORY

North Powder

Installation Date ..... 1 / 11 / 92
Local Start ..... 1 / 14 / 92
FDS Representative ..... Kenneth Benevides
FDS Job Code ..... 91 / 1090
Document Date 1/21/92

CONTROLLER/SIGN SERVICE RECORD

Service Personnel	Company	Date	Problem/Solution
M. Gronso (Couldn't get in because password not on lap-top)	ODOT	1-30-92	Primary lamp out Top row 2nd from left / Changed Lamp
M. Gronso	ODOT	2-3-92	AA led on Modem wouldnt come on / New Modem 3-5-92 2:40 p.m.
Ken Benevides	FDS	2/18/93	General checkup (See Install Notes Page)
M. Gronso	ODOT	3-10-93	Checking 4 stuck shutters / 2 freed by tapping 2 replaced
C. Reed	ODOT	"	" " " " "
M. Gronso	ODOT	10-20-93	Installed "Modem Reset Interface" in modem power cable
J. Taylor	ODOT	"	

SPECIAL FEATURES/INSTALLATION NOTES

O - Replaced shutter - 3rd Line 6th Char (C6 L7)
O - Sticky shutter - 3rd Line 17th char (C11 L?) - Tapped Free
O - Temp Sensor installed was the wrong one (4-20 mA)
Replaced with a New one (0-20 mA) (1/21/92)
O Recalibrated 1/21/92 - -4°F & -3°F (KB)

2/18/93 - General Checkup Ken Bonavich
- Cut wires 18 & 23 in modem cable
- Lamps OK, Temp Sensor OK, Trans Cabinet OK, appearance Good
Sign Consistency Good, Lamp Voltages/current up 2% - OK
K1 Relay no Problem
- 4 Bad shutters All closed - Tapped Free → 1st Line 13th char C5 L1
(M.A. 3-10-93) Replaced → 2nd Line 5th char C3 L2 & C3 L4
Tapped Free → 3rd Line 13th char C1 L7

10/20/93
INSTALLED "Modem Reset Interface"
In power cord to modem — M. Gronso
J. Taylor

LA GRANDE

SIGN HISTORY

Installation Date	1 / 11 / 92
Local Start	1 / 13 / 92
FDS Representative	Kenneth Benevides
FDS Job Code	91 / 1090
Document Date	1/21/92

CONTROLLER/SIGN SERVICE RECORD

Service Personnel	Company	Date	Problem/Solution
Ken Benevides	FDS	2/18/93	General checkup (see back)

SPECIAL FEATURES/INSTALLATION NOTES

o Replace one shutter - 3rd line 7th char (c2 L6)
o Installed thermostate in sign to controll the Front Face Heaters - set to turn on at 44°F

2/16/93

General Checkup - All lamps ok, shutters ok, tempsensor ok Appearence neat/clean/good - no problems, all voltages/current +/- 2% excellent - ~~10~~ ok KB - PDS
- cut wires 18 & 23 in modem cable

APPENDIX D

FIBEROPTIC DISPLAY SYSTEMS

FIBEROPTIC DISPLAY SYSTEMS, INC. - 90 DOUGLAS PIKE - SMITHFIELD RI 02917
TEL : (401) 232-3370 / FAX : (401) 232-7130

January 19, 1994

Mr. Arlo Bones
Oregon Department of Transportation
3700 S.E. 92nd Street
Portland, OR 97266

Subject: Upgrade to existing SYLVIA® signs

Dear Arlo,

Further to our conversation on January 13, 1994, I've provided a description of various upgrades we have done to our equipment. Also included, is a description of work that should be performed the next time the signs require service.

SUGGESTIONS:

I would like to pose the following maintenance recommendations.

1. At the next maintenance checkup, wash the inside and outside of all the front faces. After doing this, the sign will have a slightly brighter and more consistent display. This should be done once a year.

2. Clean the 2-way beam splitter mirrors.

3. Inspect the flashing beacons.

In the three years since we built your signs, we have made several design modifications. I would like to suggest these to you to upgrade your present signs.

1. Close the "old" two-way ventilation louvers in the back of the sign and install the "new" one-way vets. The new vents reduce the amount of airborne contaminants entering the sign. This increases the life of the electrical connections, reducing the buildup of dust and automobile exhaust inside the sign and on the 2-way mirrors.

2. Due to a change by the manufacturer of the lamps, we have converted from a two-piece lamp/reflector to a one-piece lamp/reflector. The new design provides for greater lamp intensity, by changing and more precisely focusing the light from the lamps on the common end of the Fiberoptic harness. There is also a 300% increase in rated life of the bulb. It will also reduce the time required to change the lamps by simplifying the process.

Cost breakdowns are:

Lamp conversion - kit only: $8.00 (this does not include any lamps)

Lamp #64004 - one piece unit with reflector: $11.85 (This is a 2,000 hour lamp.)

Lamp #64005 - one piece unit with reflector: $22.00 (This is a 6,000 hour lamp.)

Lamp conversion kit with two #64004 lamps: $28.50

Lamp conversion kit with two #64005 lamps: $50.25

The cost of the conversion kit is well worth it, when you consider the time reduction for lamp and reflector changes, and the increased life and performance of the new lamp.

3. We have converted to a mechanical locking mechanism that could be installed in place of the gas struts. Presently, there are two struts per door. Only one mechanized latch would need to be installed for every two struts. The new latches would also allow the door to open up to ≈ 135°, allowing more room and easier access to the internal parts of the sign. I'm not sure if your gas struts are discharging, you will need to inspect them.

4. Your sign is equipped with front face heating. These heaters consume ≈ 800 watts of power year-round. The heaters are only required in the winter to prevent the accumulation of ice and snow on the front face. A thermostat could be installed inside the sign, to activate the heaters, when the internal sign temperature gets below 40°F. The cost of this thermostat would pay for itself in less than one year, and extend the life of the heat strips by 300%.

If you are interested in any of these suggestions, please contact me. We will be glad to provide you with more information, as well as the cost and time required to make these changes. All of these changes could be done by your people, or if you would prefer, by FDS.

Sincerely,

Ken Benevides

Kenneth A. Benevides
Field Services Manager
Fiberoptic Display Systems, Inc.

KAB/ch
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cc: AJC, PD