ELECTRICAL CONSIDERATION

Field Survey

1. Check terrain for possible complications where traffic signal appurtenances are to be installed.

2. Check roadway condition for detector application.

3. Check rights-of-way.

4. Note underground utilities, trees, bushes, poles, walls, etc. which may not be noted on survey plans.

Utility Meeting

Arrange a field meeting on site with an electric company and a phone company engineer to determine:

1. Electric Service, type (metered or unmetered) & location and telephone service, if necessary

2. Use of existing utility poles for span and messenger where possible. Pole replacement for additional height may be less expensive than a steel pole and foundation.

3. Anchoring and guying of poles. Check right-of-way.

4. Attachment of conduit on poles and check for stand-offs.

5. Span attachment point. All span, guys, messenger, cable and conduit must be attached in accordance with Public Utility Commission Docket latest edition - "Traffic Signal Installation Practices." List span attachment heights on all utility poles (Reference No. 12).

6. Interconnect cable attachment. Determine all make-ready work such as relocations of existing utility cables, adjustment of street light brackets and pole replacements. Clearance shall be in accordance with National Electrical Safety Code and Utility Company Regulations.

7. Determine who is to do the work on the poles (normally the power company above 3 m - 10') and who will pay for the work.

8. Leave a preliminary plan with the utility company representative showing all utility pole attachments, your name and address, the electrical requirements of the signal and who will pay monthly, for the electricity. Obtain from the companies involved, in writing, a cost estimate of the work they will perform.

9. Time base coordination or spread spectrum communication should be considered where it is impossible to install cable according to Public Utility Commission regulations or where the length of the circuit makes running cable too costly.

10. The utility representative will want to know when the project will start and who will pay for work the utility company has to do. Will it be 100% reimbursable or 50% or non reimbursable? Utility companies should not schedule their work until a purchase order is received from the party requesting the work, or a written agreement is obtained from the Town or DOT.

11. Complete a meeting report and send a copy to the utility company. Reports should contain all items discussed even if there is no action required.

General

1. Determine if there are to be any trees trimmed.

2. Try not to clutter up plans with repetitious notes. Make a symbol with a corresponding note and place the symbol at the applicable location on the plan.

3. Tie down all traffic signal appurtenances to existing physical objects. Use station numbers if available. It is preferable to have controller cabinets mounted on the off-traffic side of a span pole.

4. All electrical designs to be in accordance with the National Electrical Safety Code, National Electrical Code and Utility Company regulations.

5. If there is an existing signal being replaced, determine who the owner is and direct the removed traffic signal equipment to the proper party.

6. Mast arms are usually at the same elevation as communication cables, between 5.5 m and 6.5 m (18' to 21') above the road. Therefore, utility cables should be avoided when locating mast arm structures. An adjustable mast arm assembly allows the movement up or down of the arm to avoid utility cables. Arms may be installed above communication cables. However, if the arms are so high that nipples over 0.9 m (3') are required, consider an alternate design. Fixed mounting the traffic signals allows a lower arm elevation 5.5 m to 5.8 m (18' to 19') which may be below the communication cables. Heights of cables where mast arms will cross should always be measured. Height requirements for signal heads remain at 4.9 m to 5.5 m (16' to 18').

7. Occasionally a pole or mast arm location is such that a luminaire may be attached, eliminating a light standard. In all cases, the owner of the illumination system should be contacted.

8. Combination structures require the following design considerations:

   - Service to the luminaire. Since the party responsible for the controller electricity may be different than the party responsible for the illumination electricity, service should not be from the controller cabinet. A separate conduit from the pole base for the service source is needed. This is to be confirmed with the utility representative.

   - Luminaire bracket length should be indicated on plans. Match the location of the existing luminaire or if the entire system is being designed, consult with the electrical engineer doing the illumination design.

Conduit

1. The "Conduit Design Chart" is to be used in determining conduit size. However, number of sizes should be limited based on good engineering judgment. For example, if only a short section of 75 mm 3-inch conduit is needed for design, consider using a more common size such as two 50 mm (2”).

2. All conduit shall have a minimum covering of 600 mm (24").

Conduit Design Chart

Trade Size - R.M.C.		Total Area – 100%		Useable Area - 40%	
Mm	*in*	mm^2	in^2	mm^2	in^2
25	*1*	560	*0.86*	220	*0.34*
40	*1.5*	1320	*2.04*	530	*0.82*
50	*2*	2170	*3.36*	870	*1.34*
65	*2.5*	3090	*4.79*	1240	*1.92*
75	*3*	4770	*7.38*	1910	*2.95*
90	*3.5*	6390	*9.90*	2560	*3.96*
100	*4*	8210	*12.72*	3290	*5.09*

Cable

1. Each one, two, three or four-way span wire traffic signal shall be wired by a separate cable to the cable closure.

2. Mast arm traffic signals shall be wired with separate cables to the base of the shaft - no splices in the arm.

3. A sufficient number of conductors are to be run to ensure at least one spare wire per cable.

4. Traffic signal heads on opposing legs of the artery are not to be wired in parallel.

5. Not more than four individual pedestrian signals are to be wired in parallel.

6. Cable is to be called for on the plans in the following manner:
   AWG size/No. of conductors
   (Example: 14/15, 14/5, 14/3)

7. List cables from largest to smallest 14/21, 14/15, 14/7, etc.

8. Cable size #14 = 15 amp breaker Cable size #10 = 30 amp breaker
   Cable size #12 = 20 amp breaker Cable size # 8 = 40 amp breaker

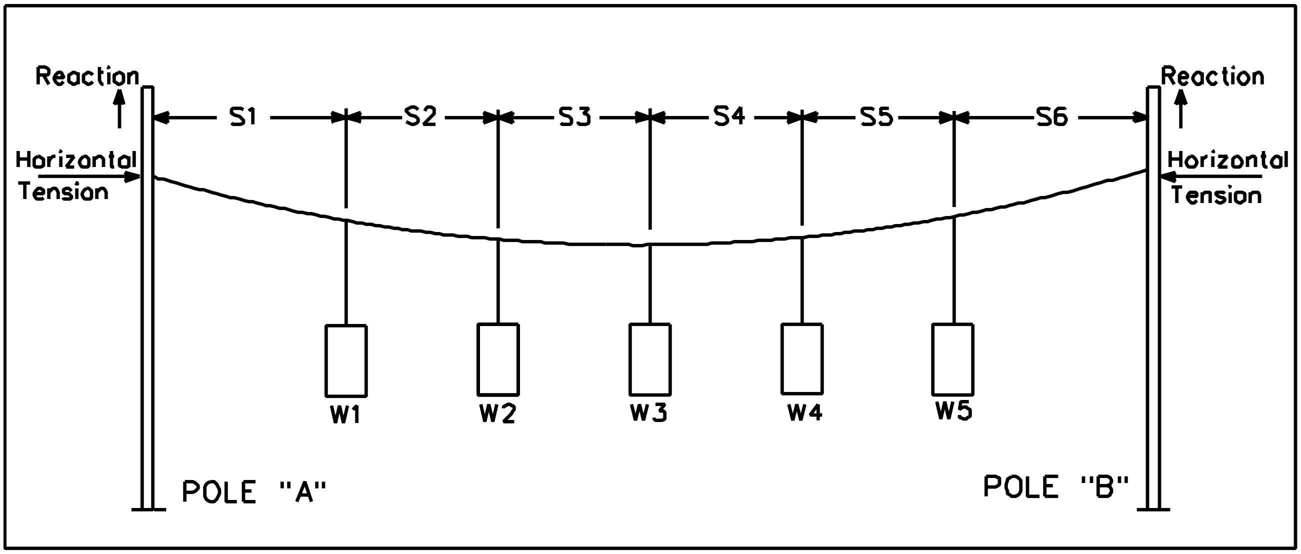
Traffic Signal Cable

Size	Diameter		Area	
	mm	*in*	mm^2	in^2
14/2	9	*.35*	60	*.09*
12/2	9	*.36*	70	*.10*
14/3	9	*.34*	60	*.09*
14/5	11	*.41*	90	*.13*
14/7	12	*.45*	110	*.16*
14/9	14	*.52*	140	*.21*
14/12	16	*.61*	190	*.29*
14/15	18	*.70*	250	*.38*
14/21	20	*.82*	330	*.53*
14/25	23	*.87*	390	*.59*

IMSA Cable Color Code

1. Cond. - Black
2. Cond. - White
3. Cond. - Red
4. Cond. - Green
5. Cond. - Orange
6. Cond. - Blue
7. Cond. - White-Black
8. Cond. - Red-Black
9. Cond. - Green-Black
10. Cond. - Orange-Black
11. Cond. - Blue-Black
12. Cond. - Black-White
13. Cond. - Red-White
14. Cond. - Green-White
15. Cond. - Blue-White
16. Cond. - Black-Red
17. Cond. - White-Red
18. Cond. - Orange-Red
19. Cond. - Blue-Red
20. Cond. - Red-Green
21. Cond. - Orange-Green
22. Cond. - Black
23. Cond. - White
24. Cond. - Red
25. Cond. - Green

Structural Design for Span Poles



Data			Outside Dimension	
200 mm (*8″*) Section	33 N	*7.5 lb.*	250 mm	*10 ″*
300 mm (*12″*) Section	67 N	*15 lb.*	350 mm	*14 ″*
			Length	
1 Way Hardware	45 N	*10 lb.*	300 mm	*12 ″*
2 Way Hardware	90 N	*20 lb.*	300 mm	*12 ″*
3 Way Hardware	110 N	*25 lb.*	300 mm	*12 ″*
4 Way Hardware	135 N	*30 lb.*	300 mm	*12 ″*
Span and Cable	14.5 N/m	*1 lb./ ft*		
Sag	5 % of span length			

NOTE: Newtons are 9.81 X Kilograms

W_1 = Signal Wt. + Hardware Wt. + Cable Wt. $(S_1 + S_2/2)$
W_2 = " " + " " + " " $(S_2 + S_3)/2$
W_3 = " " + " " + " " $(S_3 + S_4)/2$
W_4 = " " + " " + " " $(S_4 + S_5)/2$
W_5 = " " + " " + " " $(S_5/2 + S_6)$

Moments Pole A $= W_1(S_1) + W_2(S_1 + S_2) + W_3(S_1 + S_2 + S_3) + W_4(S_1 + S_2 + S_3 + S_4) + W_5(S_1 + S_2 + S_3 + S_4 + S_5)$

Reaction Pole B $= \dfrac{\text{Moments Pole A}}{S_1 + S_2 + S_3 + S_4 + S_5 + S_6}$

Moments Pole B $= W_5(S_6) + W_4(S_6 + S_5) + W_3(S_6 + S_5 + S_4) + W_2(S_6 + S_5 + S_4 + S_3) + W_1(S_6 + S_5 + S_4 + S_3 + S_2)$

Reaction Pole A $= \dfrac{\text{Moments Pole B}}{S_1 + S_2 + S_3 + S_4 + S_5 + S_6}$

Check - **Sum of Loads should equal Sum of Reactions**

$W_1 + W_2 + W_3 + W_4 + W_5 + W_6 =$ Reaction Pole A + Reaction Pole B

Low Point = Reaction Pole B - W_5 - W_4 - W_3 - etc. until the answer is a negative number. The last W subtracted is the Low Point.

OR

Reaction Pole A - W_1 - W_2 - W_3 - etc. until the answer is a negative number. The last W subtracted is the Low Point.

Sag = $.05 \text{ X } (S_1 + S_2 + S_3 + S_4 + S_5 + S_6)$

For the purpose of explanation, assume Low Point is W_3

Horizontal Tension Pole A (T) $= \dfrac{(\text{Reaction Pole A})(S_3 + S_2 + S_1) - W_2(S_3) - W_1(S_2 + S_3)}{\text{Sag}}$

Horizontal Tension Pole B (T) $= \dfrac{(\text{Reaction Pole B})(S_4 + S_5 + S_6) - W_4(S_4) - W_5(S_4 + S_5)}{\text{Sag}}$

Check - **Horizontal Tension Pole A should equal Horizontal Tension Pole B**

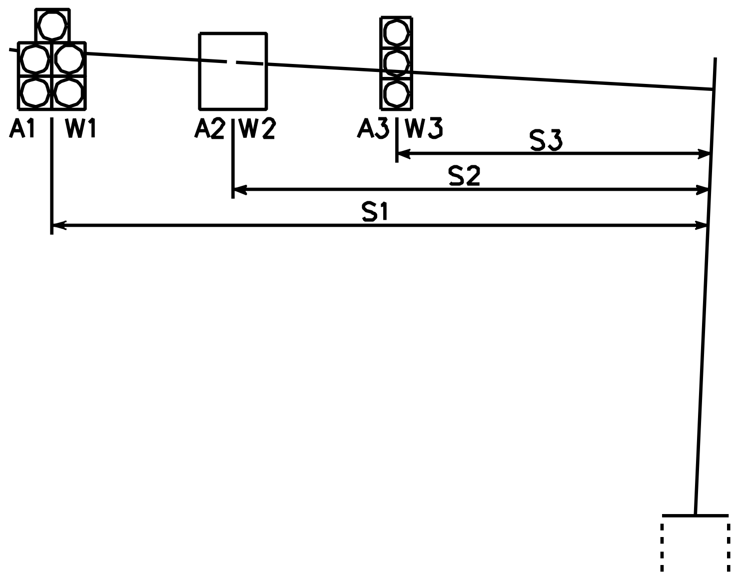
Design Tension = 2.5 T

The load at yield of the selected pole must be greater than the design tension.

Attachment Height = 4.9 m (*16'*) + Sag + Total height of largest signal or signal at low point (Minimum)*

- Assuming Flat Terrain and No Span Pole Deflection

STRUCTURAL DESIGN FOR MAST ARM ASSEMBLY



	FORCE (WEIGHT)	AREA
1 SECTION, 200 mm (8") 1 SECTION, 300mm (12")	33 N (7.5 lb) 67 N (15 lb)	.63 sq.m. (.70 sq.ft.) .123 sq.m. (1.36 sq.ft.)
3 SECTION, 200mm (8") BACKPLATE, 125 mm (5") BORDER ADD	155 N (35 lb) 22 N (5 lb)	.19 sq.m. (2 sq.ft.) .24 sq.m. (2.5 sq.ft.)
3 SECTION, 300mm (12") BACKPLATE, 125 mm (5") BORDER ADD	267 N (60 lb) 22 N (5 lb)	.37 sq.m. (4 sq.ft.) .44 sq.m. (4.7 sq.ft.)
5 SECTION, 300mm (12") BACKPLATE, 125 mm (5") BORDER ADD	443 N (95 lb) 45 N (10 lb)	.63 sq.m. (6.8 sq.ft.) 1.6 sq.m. (17.2 sq.ft.)
SIGN, 600 mm x 600 mm (24" x 24")	67 N (15 lb)	.36 sq.m. (4 sq.ft.)

NOTES :

1. DATA BASED ON CAST ALUMINUM HOUSING.
2. FORCE AND AREA VALUES INCLUDE ONE-WAY FIXED MOUNT HARDWARE.

MOMENTS = W1 (S1) + W2 (S2) + W3 (S3)

$$\text{EQUIVALENT END LOAD FORCE (WEIGHT)} = \frac{\text{MOMENTS}}{S1}$$

CACLATE EQUIVALENT END LOAD AREA, THE SAME AS FORCE (WEIGHT)

SELECT THE MAST ARM ASSEMBLY, BASED ON ARM LENGTH, FROM THE LIST OF STANDARD DESIGNS.
ARM LENGTHS GREATER THAN 14 m. (45') ARE NOT RECOMMENDED

SHAFT BOLT CIRCLE (mm)	ARM LENGTH (mm)	MIN. EQUIVALENT END LOAD	
		FORCE (N)	AREA (sq.m.)
460	6000	890	2.3
460	7000	890	2.3
460	8000	890	2.3
460	9000	890	2.3
460	10 000	890	2.8
510	11 000	1100	2.8
510	12 000	1100	2.8
510	13 000	1300	3.3
510	14 000	1300	3.3
510	15 000	1500	3.3
510	16 000	1800	3.7
560	17 000	2000	3.7
560	18 000	2000	3.7
560	19 000	2000	3.7

SHAFT BOLT CIRCLE	ARM LENGTH	MIN. EQUIVALENT END LOAD	
		WEIGHT (lbs)	AREA (sq.ft>)
18"	20'	200	25
18"	25'	200	25
18"	30'	200	25
18"	35'	200	25
20"	40'	250	30
20"	45'	300	30
20"	50'	350	35
20"	55'	400	40
22"	60'	450	40

STANDARD MAST ARM DESIGN

FIG25.dgn

Mast Arm Profile Design Guidelines

Develop a profile of the mast arm assembly. The view shall be perpendicular to the arm. The purpose of the profile is to illustrate the structure with the signals in relation to the road and also to determine the arm attachment height to the shaft.

1. Estimate the arm height over the road. The bottom of the signal housing shall have a 5.2m (17') clearance from the road[1].

    a. A fixed mounted design requires the arm to be positioned behind the center of the signal assembly. For example: A 4-section, 300mm (12") signal assembly arm should be approximately 6.0m (19'6") above the road.
    b. A free-swinging design requires the arm to be at least 0.3m (1') higher than the longest signal assembly. This is to allow for the hanger hardware.

2. Calculate the vertical rise of the arm. Multiply the length of the arm by the tangent of the 3-degree attachment angle.

3. Determine the difference in the elevation of the top of the proposed foundation and the highest point of the road beneath the arm.

4. Determine the arm attachment point to the shaft. Subtract the vertical rise from the estimated arm height over the road. If the elevation of the proposed foundation is higher than the road, subtract the difference. If the proposed foundation is lower, add the difference. Round up to the nearest 0.5m if dimensions are metric, one foot if dimensions are English.

5. Determine the shaft height.

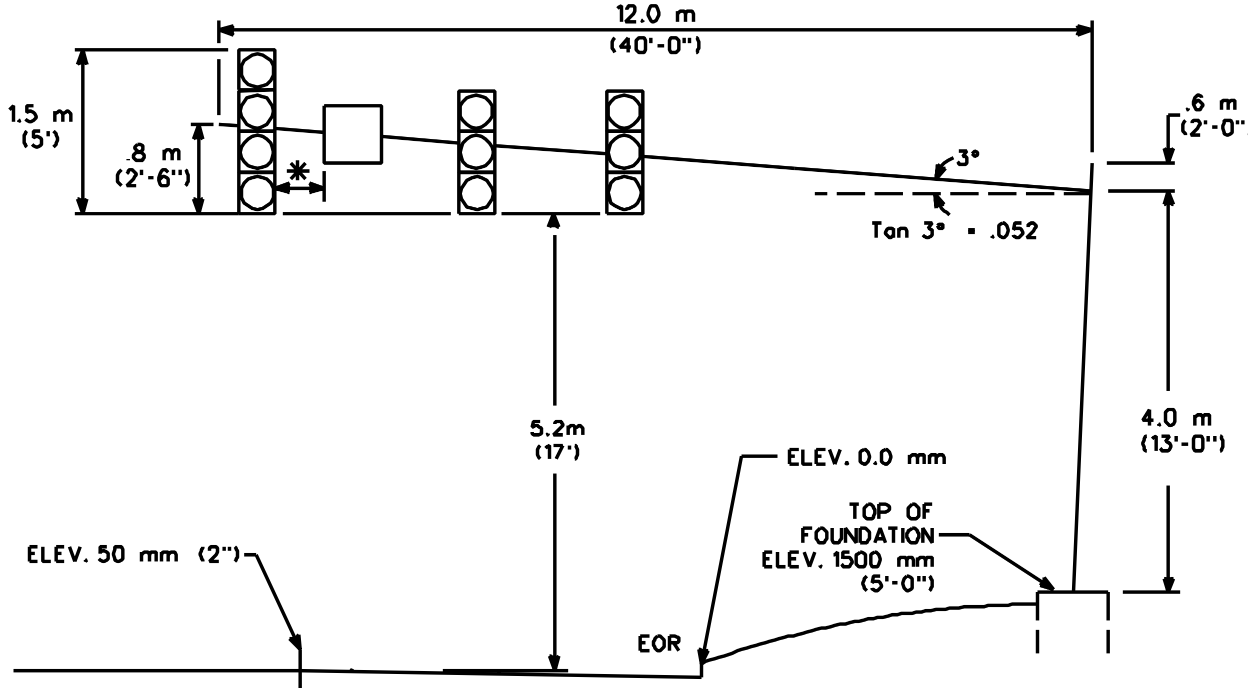
    a. Adjustable clamp designs are preferable. If the designer specifies an adjustable clamp, the shaft height shall be 0.6m (2') higher than the attachment point. The clamp has a 1.0m (3') range and the attachment point should be in the middle, 0.5m (18") up and 0.5m (18") down.
    b. If the designer specifies a non-adjustable, welded attachment, the shaft height is 0.3m (1') higher than the attachment point.

Miscellaneous:

- A design using fixed-mounted signals attached to an adjustable arm is preferred.
- When signals are designed as fixed-mounted, all mast-arm-mounted signs shall be fixed also.
- When the arm is attached to the shaft, the combined weight of the arm and signals will deflect arm. The deflection is greater on longer arms. The actual rise will be less than that calculated above.
- If there is enough space on the signal plan under the construction notes, the profile may be shown there. If not, the profile should be shown on separate 2 ft.x3 ft. sheets (refer to pages 119 or 133).

[1] 5.2m (17') was chosen for design purpose. Acceptable distance is 4.9m (16') to 5.5m (18').

TYPICAL MAST ARM DETAIL



ADJUSTABLE MAST ARM DESIGN EXAMPLE

NO SCALE

* Distance between sign and signal head should be 0.15 m Minimum

1) Arm Height = 5.2 m + 0.8 m = 6.0 m
2) Vertical Rise = (12.0 m) .052 = 0.6 m
3) Foundation is 1450 mm above road
4) Attachment Point = 6.0 m - 0.6 m - 1.45 m = 3.95 m rounded up to 4.0 m
5) Shaft Height = 4.0 m + 0.6 m = 4.6 m

FIG20.DGN

Loop Detector Design

A loop detector amplifier will operate more consistently and be more reliable when the loop, or loops, it is connected to has the correct inductance. The loops should be installed and spliced to provide an inductance between 70 ohms and 400 ohms. Optimum inductance is 200 ohms. Segmented loops should be spliced in series not parallel. The loop inductance should be greater than the lead in inductance of the 14/2 cable from the handhole to the controller. The calculated inductance for each loop should be recorded on the loop detector test data chart.

Inductance calculations (metric):

L = Inductance in Microhenrys - µh

N = Number of turns of wire

P = Perimeter of Loop in meters

C = Length of 14/2 cable from handhole to controller in meters

$L_{loop} = (3.28\ P/4)(N^2 + N)$

$L_{14/2} = 0.78\ \mu h/m \times C$

Inductance calculations (English):

L = Inductance in Microhenrys - µh

N = Number of turns of wire

P = Perimeter of Loop in feet

C = Length of 14/2 cable from handhole to controller in feet

$L_{loop} = (P/4)(N^2 + N)$

$L_{14/2} = 0.24\ \mu h\ /ft \times C$

Type of Service

The electrical service to a traffic signal is provided by the local utility company. The service may be **Metered** or **Unmetered** depending on state needs and utility regulations. The majority of signalized intersections have unmetered service. The type of service "metered" or "unmetered" service, must be listed on the signal plan above the signal face block.

United Illuminating and Wallingford Electric require metered service for most traffic signal installations.

Energy Information

Energy by: State, Town, Developer or Shopping Center Owner

Service Pole #: Indicate the utility pole number where secondary service is attached. The pole number is to aid in the positive identification of the intersection for billing purposes.

Overlaps

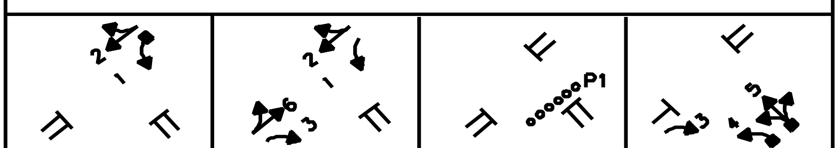
Each phase has a green, yellow and red output from the controller to the signal heads which control the indications. An overlap occurs whenever a movement is serviced in more than one phase. In this case the indications are driven by the overlap outputs rather than the standard phase outputs. An overlap program can include any number of phases servicing that one movement. The controller can only accept four overlap programs, either standard, non-standard or a combination of both.

Standard Overlap

In a standard overlap the green, yellow, red indications on the signal head is the same as the green, yellow, red overlap output from the controller. When the controller goes to a phase that is not in the overlap program, the clearance indications will be shown. The face 1 green arrow and yellow arrow is strictly for phase 1. The circular green, yellow, red is a standard overlap of phase 1 + phase 2. Refer to the diagram below.

Non-standard Overlap

Non-standard overlaps are to be avoided; however, at times are necessary. In a non-standard overlap, the green, yellow, red overlap outputs are altered by circuitry external to the controller to provide the sequence desired. Usually this happens with a right turn arrow. The green indication does not remain on during all phases of the overlap program. Occasionally the yellow and red indications are not displayed either. Refer to face 3 below. The circular green, yellow and red indications are strictly for phase 2. The green arrow and yellow arrow is phase 2 + phase 4 (overlap) minus the phase 2 green and yellow outputs. The overlap red output is not used. Technical notes are required to clarify the sequence when phases are skipped and there may be an alternate indication.



NONE														
NTOR			PHASE 1			PHASE 2			PHASE 3			PHASE 4		
		FLASH	GRN	CL	CL	GRN	CL	CL	GRN	CL	CL	GRN	CL	CL
FACE #	1	R	←G	←Y G	G	G	Y	R	R	R	R	R	R	R
	2	R	G	G	G	G	Y	R	R	R	R	R	R	R
	3	R	R	R	R	G	Y (1)	R (2)	R	R	R	R→	R Y→ (3)	R (3)
	4	R	R	R	R	R	R	R	R	R	R	G	Y	R
	5	R	R	R	R	R	R	R	R	R	R	G	Y	R
	6	R	R	R	R	G	Y	R	R	R	R	R	R	R
	P	OFF	←		DW			→	WØ	←		DW		→

TECHNICAL NOTES

(1) TO BE Y → IF PHASE 4 IS NEXT.

(2) TO BE R → IF PHASE 4 IS NEXT.

(3) TO BE R → IF PHASE 2 IS NEXT.

FIG22.DGN