ANNUAL METEOROLOGICAL MONITORING TOWER INSPECTIONS - MAINTAINING SAFETY AND EXPOSURE TO WIND

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Abstract

A program for maintaining meteorological monitoring towers at nuclear facilities will be discussed. Annual tower inspections are performed and are in compliance with the guidelines set forth in the ANSI/TIA/EIA-222-F-1996 document "Structural Standards for Steel Antenna Towers and Antenna Supporting Structures." Annual inspections include a multi-point checklist. The purpose of the inspection is to identify any needed tower maintenance. The results of the inspection are documented and reported along with any recommendations for corrective action. The annual program also includes routine and as needed tower lighting maintenance.

A second program has been established for performing annual site surveys of the area surrounding meteorological monitoring towers at nuclear facilities. Annual surveys are based upon guidance from ANSI/ANS 3.11-2000, "Determining Meteorological Information at Nuclear Power Plants" and NRC Regulatory Guide 1.23, "Meteorological Programs in Support of Nuclear Power Plants." The purpose of the site surveys is to locate any obstruction to "natural" wind flow. Procedures and methods used to perform and document the site surveys will be presented. The methodology used for determining existing and potential obstructions to air flow will be detailed along with the use of photographs to document the existing site conditions.

ANNUAL METEOROLOGICAL MONITORING TOWER INSPECTIONS

Tower inspections are performed on an annual basis with the following goals in mind:

- Minimize the liability exposure of the tower owner with respect to the owner's employees, maintenance personnel and the general public;
- Extend the life of the tower structure; and
- Conform to existing laws and regulations governing the lighting, integrity and safety of the structure.

Tower inspections are performed annually to determine what, if any, deficiencies exist. Any deficiencies determined as a result of the annual inspection are corrected in a timely manner consistent with maintaining safe conditions and conforming to applicable regulations. A report of all applicable tests, adjustments and inspections are provided to the tower owner whenever the annual inspection is performed.

As a part of the annual tower maintenance procedures, the obstruction lamp bulbs (flashing beacons and sidelights) are replaced on an as needed basis and on a scheduled semi-annual basis. Maintaining of painting to FAA specifications is also included as part of the tower maintenance.

During quarterly meteorological calibrations, the tower lighting, including the beacon and sidelights, wiring and flasher are checked and replaced or repaired as needed. Quarterly, the paint and guy wire tension conditions are also checked and documented.

Towers are inspected and maintained using the guidance of the American National Standards Institute/Telecommunications Industry Association/Electronic Industries Association document, ANSI/TIA/EIA-222-F-1996 "Structural Standards for Steel Antenna Towers and Antenna Supporting Structures." Annex E of the aforementioned document pertains to tower maintenance and inspection procedures. Annex E states that owners should perform initial and periodic tower inspections and maintenance to assure safety and to extend service life. It is recommended that major inspections be performed, at a minimum, every 3 years for guyed towers and every 5 years for self-supporting towers. Section 14 of ANSI/TIA/EIA-222-F-1996 recommends that all structures be inspected after severe wind and/or ice storms or other extreme loading conditions. It is also recommended that shorter inspection intervals be considered for structures in coastal salt water environments, in corrosive atmospheres and in areas subject to vandalism.

Current Murray and Trettel procedures call for annual tower inspections as compared the minimum 3-year inspections recommended by ANSI/TIA/EIA-222-F-1996. The reasons for annual inspections include safety, especially for tower climbing personnel and budgeting for tower maintenance. Tower inspections generally cost from $1,200 to $1,500 depending on the height of the tower. One plant that performed tower inspections every three years found their tower required over $14,000 in maintenance. Fees for the required maintenance were required to be found in the current year's budget. Earlier detection of required tower maintenance would likely have made the budgeting process less painful. Annual inspections can often lead to preventative maintenance, which is often much less expensive than required maintenance.

The following tower conditions are inspected annually (see check list which is derived from ANSI/TIA/EIA-222-F-1996):

- Inspect for bent leg and lacing members, loose or missing members, for secure climbing facilities (platforms, catwalks, etc.) and loose and/or missing bolts.
- Check paint and/or galvanizing condition, rust and/or corrosion conditions, FAA or ICAO color marking conditions and water collection in any members.

- Check lighting conduit, junctions boxes and fasteners to be weather-tight and secure, drains and vents open as required, wiring condition, functioning of controller (flasher and photo control), light lenses and bulb condition.

- Check for secure grounding connections, corrosion and lightning protection.
- Check tower base foundation for settlements or movements and erosion, and site condition for standing water, drainage problems, trees, or other impediments.
- Check base condition for tight nuts and lock nuts, grout condition.
- Check concrete base for cracking, spalling or splitting; chipped or broken condition; honeycombing; low spots to collect moisture; and anchor-bolt condition.
- Check tower alignment for plumb within 1 part in 400 and linearity maximum deviation from a straight line between any points less than 1 part in 1000.

For guyed towers:

- Check guy anchors for settlement, movement or earth cracks; anchor rod condition below earth (12 in. minimum); corrosion; grounding; and anchor head clear of earth.
- Guy cable should be checked for corrosion, breaks, nicks, kinks or any other detrimental condition.
- Guy turnbuckles should be secure and safety properly installed; the guy thimbles and service sleeves properly in place; cable clamps applied properly and bolts tight, any performed wraps properly applied, strandvices secure; and poured sockets secure and showing no sign of separation.
- Check shackles, bolts, pins and cotter pins to be secure and in good condition.
- Check guy tension for manufacturer's recommendations by acceptable methods. Guy tension may be tested using a dynamometer with a length adjustment device, the Pulse Method and the Tangent Intercept Method (all three methods are described in TIA/EIA-222-F).
- Record tensions and weather conditions on suitable forms.

Minor variations in guy tensions are to be expected due to temperature and wind. Should there be any significant tension changes, the cause should be determined immediately and proper remedial action taken. Possible causes may be initial construction loosening, extreme wind or ice, anchor movements, base settlement or connection slippage.

Variations at a single level are to be expected because of anchor elevation differences, construction deviations and wind effects.

Guy wire tension should not be checked or adjusted during times of excessive winds.

The following is an example of an inspection conducted during 2002, including pictures. The required maintenance has since been completed. Also included is an example of a new inspection log, which has been implemented in 2003.

Krueger Tower Incorporated
Tower Inspection report
as per ANSI/TIA/EIA-222-F-1996

Site: **Tower #** N/A **Date:** 11-13-02 **Time:** 9:30

Wind speed: 15 **Wind direction:** 180 **Temp.(°F)** 50

Structure type: 200' guyed

Item	Acceptable	Maintenance Required	Not Applicable
1.) Alignment	X		
2.) Antennas	X		
3.) Feed lines		X	
4.) Finish		X	
5.) Foundation	X		
6.) Grounding	X		
7.) Guy anchors	X		
8.) Guy cables		X	
9.) Guy hardware		X	
10.) Guy insulators	X		
11.) Guy tensions		X	
12.) Lighting	X		
13.) Members	X		
14.) Hardware		X	

Notes: Guy azimuths are taken from in field compasss measurements for referencing purposes and may not precisely agree with construction and engineering documentation.

Tower Leg Vertical Alignment (as found)

Transit #1 — Facing (degrees) 40 — Tower Lays

Guy Level	Left inches	0	Right inches
190	1.5"		
160	.75"		
120		O.C.	
80	.5"		
40	.25"		

Transit #2 — Facing (degrees) 130 — Tower Lays

Guy Level	Left inches	0	Right inches
190	1"		
160	1"		
120	.5"		
80		O.C.	
40		O.C.	

Tower Leg Vertical Alignment (as left)

Transit #1 — Facing (degrees) 40 — Tower Lays

Guy Level	Left inches	0	Right inches
190	1.5"		
160	.75"		
120		O.C.	
80	.5"		
40	.25"		

Transit #2 — Facing (degrees) 130 — Tower Lays

Guy Level	Left inches	0	Right inches
190	1"		
160	1"		
120	.5"		
80		O.C.	
40		O.C.	

Figure 1.

Guy Cable Tensions

method(s) [X] Dynamometer [ ] pulse [ ] tangent intercept

guy azimuth: 40

Guy Level	Guy Diameter	initial Tension lbs (target*F)	initial Tension lbs (as found)	% out (as found)	final Tension lbs (target*F)	final Tension lbs (as left)	% out (as left)
190	5/16"	1160	800	-31.0%	1160	800	-31.0%
160	5/16"	1160	800	-31.0%	1160	800	-31.0%
120	5/16"	1160	1300	12.1%	1160	1300	12.1%
80	5/16"	1160	1050	-9.5%	1160	1050	-9.5%
40	5/16"	1160	1300	12.1%	1160	1300	12.1%

guy azimuth: 160

Guy Level	Guy Diameter	initial Tension lbs (target*F)	initial Tension lbs (as found)	% out (as found)	final Tension lbs (target*F)	final Tension lbs (as left)	% out (as left)
190	5/16"	1160	800	-31.0%	1160	800	-31.0%
160	5/16"	1160	800	-31.0%	1160	800	-31.0%
120	5/16"	1160	1250	7.8%	1160	1250	7.8%
80	5/16"	1160	1050	-9.5%	1160	1050	-9.5%
40	5/16"	1160	1150	-0.9%	1160	1150	-0.9%

guy azimuth: 280

Guy Level	Guy Diameter	initial Tension lbs (target*F)	initial Tension lbs (as found)	% out (as found)	final Tension lbs (target*F)	final Tension lbs (as left)	% out (as left)
190	5/16"	1160	900	-22.4%	1160	900	-22.4%
160	5/16"	1160	900	-22.4%	1160	900	-22.4%
120	5/16"	1160	1050	-9.5%	1160	1050	-9.5%
80	5/16"	1160	1200	3.4%	1160	1200	3.4%
40	5/16"	1160	1200	3.4%	1160	1200	3.4%

Inspection by: ____________

Date: 11-13-02

Figure 2.

Item 8

Items 8 & 9

Item 4

Item 4

Item 4

Item 3

Figure 3.

Item 14

Item 3

Item 14

Item 14

Tower missing leg bolt

Figure 4.

TWIST AND OUT-OF-PLUMB DETERMINATION FOR SQUARE TOWERS

site:
date:
wind speed:
wind direction:
temperature:
D1 Facing:
D2 Facing:
D3 Facing:
D4 Facing:

observed mast data						calculated twist			calculated out of plumb		
mast elev. in feet	A (inches)	D1(inches)	D2 (inches)	D3 (inches)	D4 (inches)	d (inches)	e	a (degrees)	x (inches)	y (inches)	r (inches)
						0	ERR	ERR	0	0	0
						0	ERR	ERR	0	0	0
						0	ERR	ERR	0	0	0
						0	ERR	ERR	0	0	0
						0	ERR	ERR	0	0	0
						0	ERR	ERR	0	0	0
						0	ERR	ERR	0	0	0
						0	ERR	ERR	0	0	0
						0	ERR	ERR	0	0	0
						0	ERR	ERR	0	0	0
						0	ERR	ERR	0	0	0
						0	ERR	ERR	0	0	0
						0	ERR	ERR	0	0	0
						0	ERR	ERR	0	0	0

Figure 5.

Krueger Tower Incorporated

Guy Cable Tensions

initial measurements	Date	Time
Temp.(*F)	wind speed	direction

final measurements	Date	Time
Temp.(*F)	wind speed	direction

method(s)				
	Dynamometer	pulse	tensiometer	tangent intercept

guy azimuth

Guy Level	Guy Diameter	initial Tension lbs *(required)*	initial Tension lbs *(as found)*	initial % out *(as found)*	final Tension lbs *(required)*	final Tension lbs *(as left)*	final % out *(as left)*
				ERR			ERR
				ERR			ERR
				ERR			ERR
				ERR			ERR
				ERR			ERR
				ERR			ERR
				ERR			ERR
				ERR			ERR

guy azimuth

Guy Level	Guy Diameter	initial Tension lbs *(required)*	initial Tension lbs *(as found)*	initial % out *(as found)*	final Tension lbs *(required)*	final Tension lbs *(as left)*	final % out *(as left)*
				ERR			ERR
				ERR			ERR
				ERR			ERR
				ERR			ERR
				ERR			ERR
				ERR			ERR
				ERR			ERR
				ERR			ERR

guy azimuth

Guy Level	Guy Diameter	initial Tension lbs *(required)*	initial Tension lbs *(as found)*	initial % out *(as found)*	final Tension lbs *(required)*	final Tension lbs *(as left)*	final % out *(as left)*
				ERR			ERR
				ERR			ERR
				ERR			ERR
				ERR			ERR
				ERR			ERR
				ERR			ERR
				ERR			ERR
				ERR			ERR

Figure 6.

Krueger Tower Inc.

Site Name__________________ Date__________________ Inspected by _________

	Acceptable	Maintenance Required	N/A
1. Tower Conditions			
A. Members			
1. Bent Members	☐	☐	☐
2. Loose Members	☐	☐	☐
3. Missing Members	☐	☐	☐
4. Climbing facilities (all secure)	☐	☐	☐
5. Platforms, catwalks (all secure)	☐	☐	☐
6. Loose and/or missing bolts	☐	☐	☐
7. Water collection in members	☐	☐	☐
B. Finish			
1. Paint and/or galvanizing condition	☐	☐	☐
2. Rust and/or corrosion conditions	☐	☐	☐
3. FAA or ICAO color marking	☐	☐	☐
C. Lighting			
1. Components weather tight	☐	☐	☐
2. Components secure	☐	☐	☐
3. Drains and vents open	☐	☐	☐
4. Wiring condition	☐	☐	☐
5. Controllers functioning			
A. Flasher	☐	☐	☐
B. Photo control	☐	☐	☐
C. Alarms	☐	☐	☐
6. Light lenses	☐	☐	☐
7. Bulb condition	☐	☐	☐
D. Grounding			
1. Connections secure	☐	☐	☐
2. Corrosion	☐	☐	☐
3. Lightning protection secure	☐	☐	☐
E. Tower base foundation			
1. Ground conditions			
a. Settlements or movement	☐	☐	☐
b. Erosion	☐	☐	☐
c. drainage, trees, etc.	☐	☐	☐
2. Base condition			
a. Nuts and lock nuts tight	☐	☐	☐
b. Grout condition	☐	☐	☐
3. Concrete condition			
a. Cracking, spalling or splitting	☐	☐	☐
b. Chipped or broken concrete	☐	☐	☐
c. Honeycombing	☐	☐	☐
d. Low spots collecting moisture	☐	☐	☐
e. Anchor bolt corrosion	☐	☐	☐
F. Tower alignment			
1. Tower plumb and twist	☐	☐	☐
G. Insulators			
1. Insulator condition			
a. Cracking or chipping	☐	☐	☐
b. Spark gaps set properly	☐	☐	☐
c. Isolation transformer condition	☐	☐	☐
d. Bolts and connections secure	☐	☐	☐
H. Safety climb device	☐	☐	☐

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Figure 7.

Krueger Tower Inc.

Site Name________________ Date________________ Inspected by ________

	Acceptable	Maintenance Required	N/A
2. Guyed towers			
A. Anchors			
1. Settlement or movement	☐	☐	☐
2. Backfilled to shed water	☐	☐	☐
3. Anchor rod condition below grade	☐	☐	☐
4. Corrosion	☐	☐	☐
5. Anchor head clear of earth	☐	☐	☐
B. Tower guys			
1. Strand condition	☐	☐	☐
2. Guy hardware			
a. Turnbuckles and safety wraps	☐	☐	☐
b. Cable thimbles	☐	☐	☐
c. Service sleeves (if required)	☐	☐	☐
d. Cable connectors	☐	☐	☐
e. Shackles, bolts and pins	☐	☐	☐
3. Guy tensions			
a. tensions within tolerance	☐	☐	☐
4. Guys grounded properly	☐	☐	☐
3. Antennas and feedlines			
A. Antenna mounts and antennas			
1. Members (mounting and stabilizing)	☐	☐	☐
2. Adjustments secure and locked	☐	☐	☐
3. Element and radome condition	☐	☐	☐
B. Feedlines			
1. Hangers and supports			
a. Condition	☐	☐	☐
b. Quality	☐	☐	☐
c. Spacing	☐	☐	☐
2. Line condition	☐	☐	☐
3. Weather sealing	☐	☐	☐
4. Grounds	☐	☐	☐
5. Ice shields			
a. Properly attached	☐	☐	☐
b. Grounded	☐	☐	☐

Notes:
Highest point above tower structure

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Figure 8.

ANNUAL SITE SURVEYS

Site surveys (sometimes referred to as tree inspections) are performed annually. The inspections are performed to determine and document if any obstacles exist which may modify airflow in the vicinity of meteorological monitoring towers.

Obstructions to airflow may be manmade or natural. In most cases towers were sited in locations where manmade obstructions did not exist and natural vegetation was minimal or non-existent. As nuclear plants have aged, so to has the natural vegetation. In some locations, cutting or topping trees and other vegetation has become a necessity. The question then becomes, what needs to be cut?

Guidance concerning obstructions to airflow vary slightly in their interpretation of required tower clearance from obstructions. Dating back to 1980 and the proposed revision to Regulatory Guide 1.23, Meteorological Programs in Support of Nuclear Power Plants, states "The height of natural or man-made obstructions to air movement should ideally be lower than the measuring level to a horizontal distance of 10 times the measuring level height." This interpretation would indicate that for wind measurement at 10 meter (33 feet), obstructions should be below 10 meters to a distance of 100 meters or 328 feet. This implies that an object 30 feet in height could be within proximity to the monitoring tower (see Figure 9).

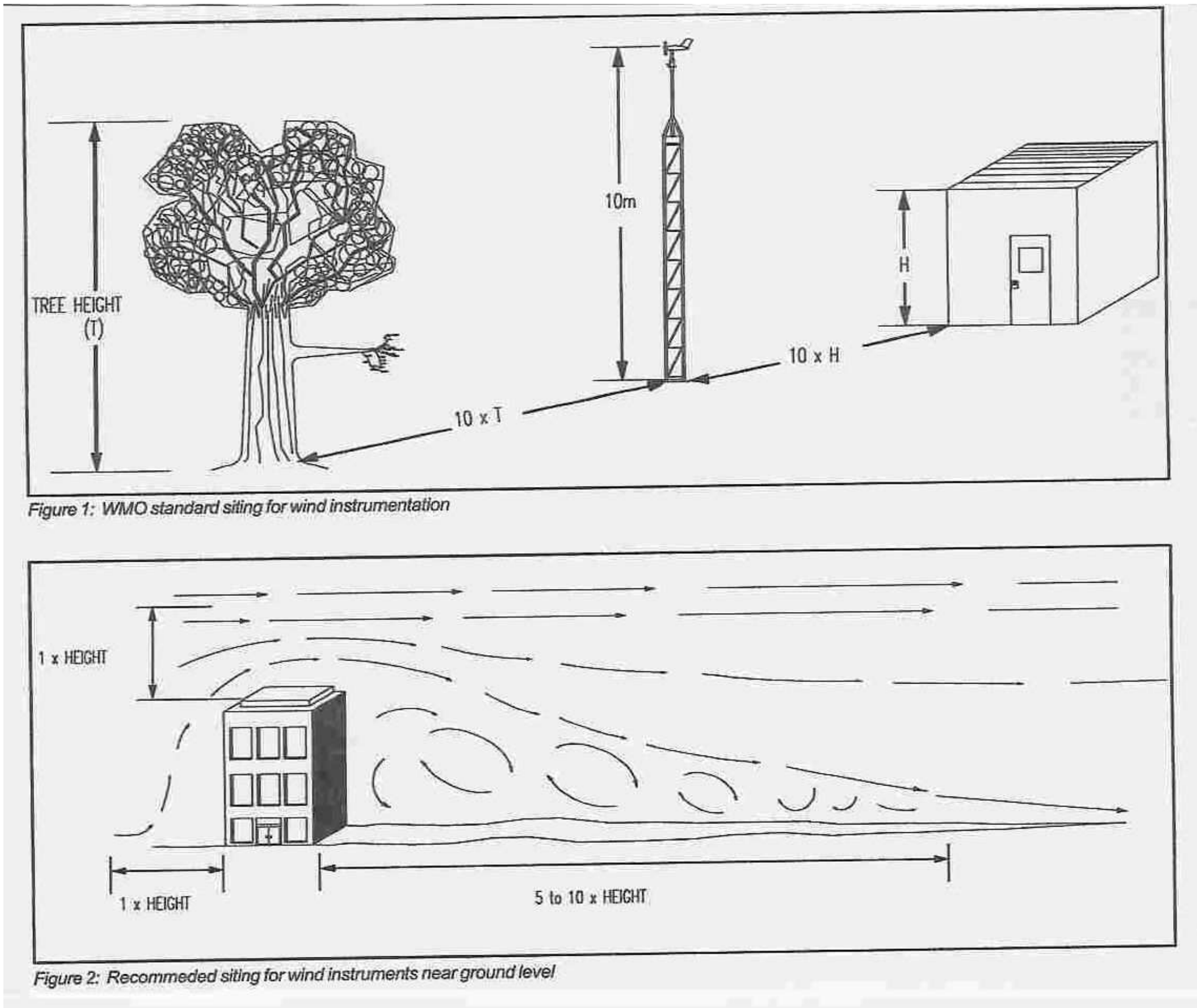

Figure 9.

ANS-3.11-2000, Determining Meteorological Information at Nuclear Facilities section 4.3.1 indicates that "Wind measurements shall be made at locations and heights that avoid airflow modifications by obstructions such as large structures, large trees, or nearby terrain with heights exceeding one-half the height of the wind measurement. The separation between an anemometer and the obstruction should be ten times the obstruction height. Measurements made with less separation may be adversely influenced by airflow changes caused by the obstructions. The separation can be reduced to about five times the height for objects with cross-sectional dimensions less than about one meter, such as utility poles or small trees." ANS 3.11 implies that obstructions within 50 meters of a tower measuring wind at 10 meters should not exceed a height of 5 meters. Also, the distance from the tower to potential obstructions should be at least 10 times the height of the obstruction, provided the obstruction is at least 1 meter in diameter (a 20 meter obstruction should at a minimum be 200 meters distant from the monitoring tower).

ANS 3.11, section 4.3.1, references ASTM D-5741-96, Standard Practice for Characterizing Surface Wind Using a Wind Vane and Rotating Anemometer. ASTM D-5741-96, section 4.1.2 suggests that wind sensors at 10 meters should have an open fetch of at least 150 meters (@500 feet) in all directions. Also, obstacles in the vicinity should be at least ten times their own height distant from the wind sensors.

Another document referenced by ANS 3.11 is the Federal Standard for Siting Meteorological Sensors at Airports, FCM-S4-1004. This standard states that wind sensors should be 15 feet above any object within 500 feet of the sensor and 10 feet higher than any obstruction between 500 and 1000 feet. Also, vegetation within 100 feet of any meteorological monitoring sensor should not be higher than 10 inches.

A simple method has been developed in recent years to determine obstructions to wind flow in the vicinity of meteorological monitoring equipment at nuclear facilities. The method includes utilizing equipment to measure the angle subtended by the object in relation to the surface, distance measuring equipment, a compass and a camera mounted on a tripod.

At many meteorological monitoring towers, it is easy to determine which objects are, or may be, obstructions to wind flow. The height of an object is determined using the angle subtended by the object along with the distance from the tower indicated by the range finding equipment. From the above information, the height of the object can be estimated with adequate accuracy.

Figure 10 is a simplified diagram of how the system works. The range to the object (a tree in this case) is measured with an optical range finder and the angle is measured with a homemade sighting device similar to a hypsometer. To measure the angle, the observer sights the scale zero point on the base of the object and reads the scale where he/she sees the top of the object. To simplify the observer's calculation, the scale is graduated in the tangent of the angle. Thus, given the range finder's range, the height can be found with one multiplication.

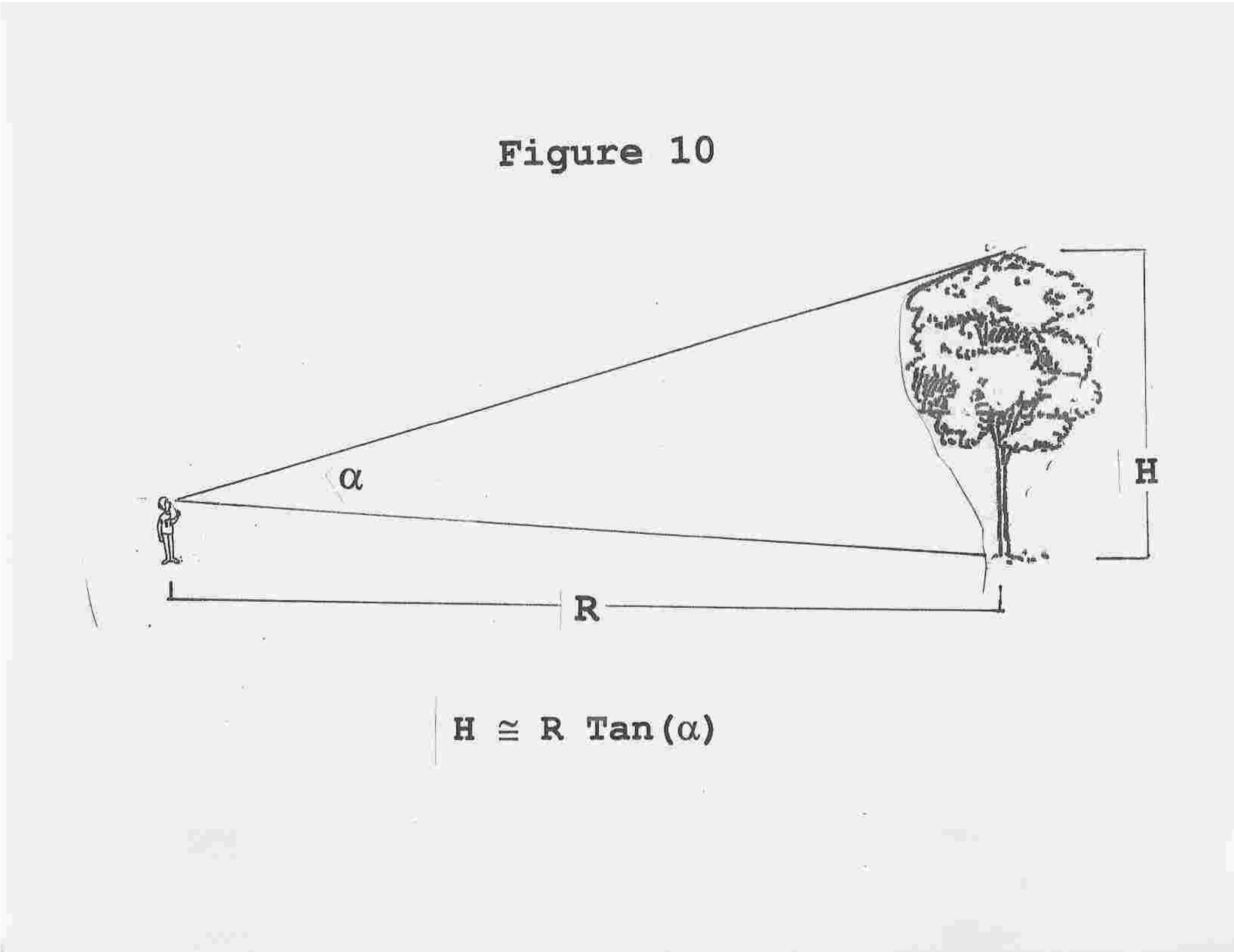

Figure 10.

Obstructions and potential future obstructions are logged based on range, height and compass direction from tower. After the logging of the obstructions is complete, photographs are taken (using a digital camera) of the entire site. A minimum of eight pictures are taken to cover the full 360 degrees surrounding the site (N, NE, E, SE, S, SW, W, NW).

Once the pictures are brought back to the office, they are labeled by site name and direction. Pictures that have trees or other obstructions to wind flow are highlighted on the images. The obstructions are marked indicating whether they are obstructions based upon Reg. Guide 1.23 or ANS 3.11 criteria. The photos are included once a year as part of a routine monthly report, which is distributed to each facility. Each facility responds to the report findings accordingly.

Since the goal of this survey is to keep obstructions at or below a certain level, some approximations are acceptable. Overall, it is believed that the readings are accurate within one or two feet and that more accuracy is not needed for this particular survey. The error tends to be larger at closer ranges.

Site survey log

Site: A **Date:** 8/26/2003

sector	Range	height of object	Required height	Reg.(NRC/ANS)	Notes:
0°	504 FT.				Group of trees from 0 to 20
10°	504 FT.	83 FT.	50.4 FT.	ANS	degrees averaging 83 feet.
20°	504 FT.				
30°					
40°					
50°					
60°					
70°					
80°					
90°					
100°					
110°					
120°					
130°					
140°					
150°					
160°					
170°					
180°					
190°					
200°					
210°					
220°					
230°					
240°					
250°					
260°					
270°					
280°	483 FT.				
290°	483 FT.	77 FT.	48.3 FT	ANS	Group of trees from 280 to 300
300°	483 FT.				degrees averaging 77 feet.
310°					
320°	420 FT.				
330°	420 FT.	55 FT.	42 FT.	ANS	Group of trees from 320 to 340
340°	420 FT.				degrees averaging 55 feet.
350°					

Comments:

Technician(s): MTC, TJB, AJL

Murray & Trettel, Inc. e-mail: mt@weathercommand.com http: www.weathercommand.com phone: (847) 446-7800

Figure 11.

This procedure allows one or two people to evaluate the site in a relatively short time. Figure 11 is a data sheet prepared during a survey and Figure 12 shows one of the photographs, which has been highlighted to show a problem area.

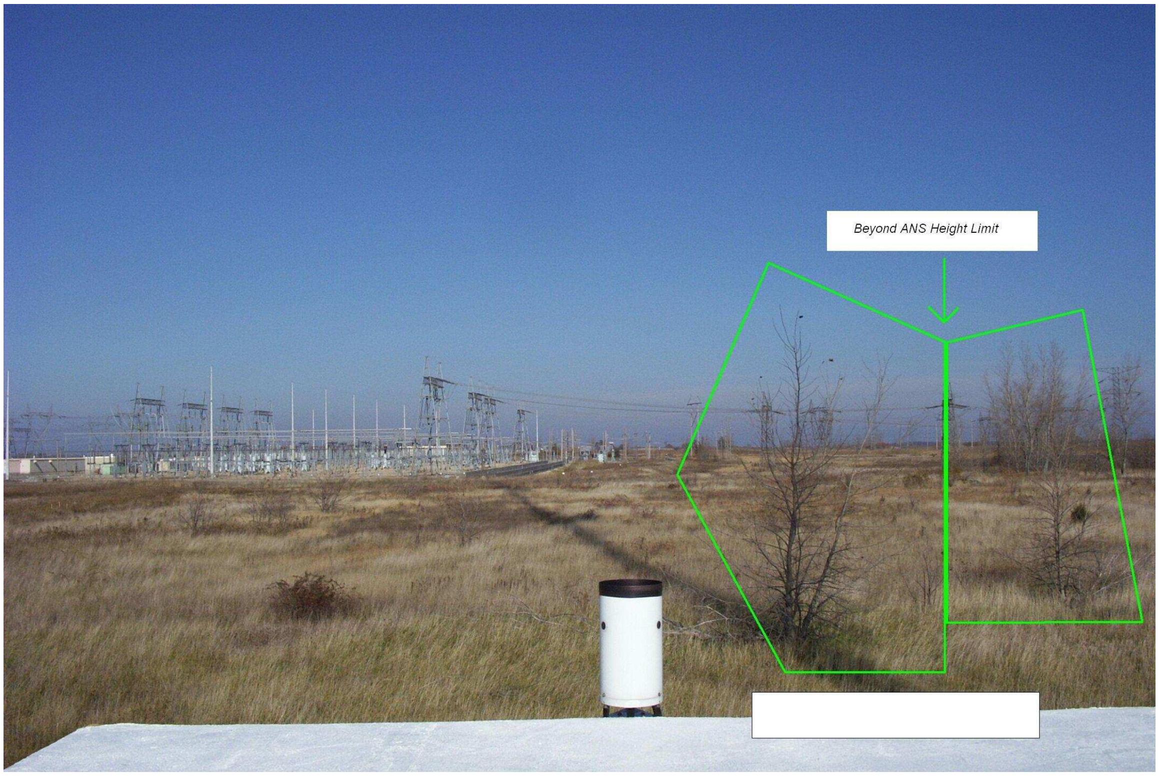

Figure 12.

This methodology was designed not only to catch existing problems but also to locate potential future problems such as trees that may become a problem in a few years.