

MICROWAVE SYSTEMS

DEP 32.71.00.31-Gen.

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DESIGN AND ENGINEERING PRACTICE



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1. INTRODUCTION

1.1 SCOPE

This new DEP specifies requirements and gives recommendations for the use, design and installation of microwave systems. It supplements DEP 32.71.00.10-Gen. and DEP 32.71.00.12-Gen. Reference is made to DEP 32.71.00.11-Gen. and DEP 32.71.00.14-Gen.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIOP and SIEP, the distribution of this DEP is confined to companies forming part of the Royal/Dutch Shell Group or managed by a Group company, and to Contractors nominated by them (i.e. the distribution code is "C", as described in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil refineries, gas plants, chemical plants, exploration and production facilities, and supply/marketing installations.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal. In this DEP the term "Company" has the same meaning as "Principal".

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.4 ABBREVIATIONS

BER	Bit error rate
CDMA	Code division multiple access
DAMA	Demand assigned multiple access
ITU	International Telecommunication Union
PTT	Post, telegraph and telephone company
QAM	Quadrature amplitude modulation
QPSK	Quaternary phase shift keying
VSWR	Voltage standing wave ratio

1.5 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced in this DEP are listed in (7).

2. APPLICATION

When there is a requirement to provide voice telephony, data, television or alarm signals to remote sites or to link field offices, the first choice is generally copper or fibre optic cable. Microwave should be considered if:

- long distances need to be covered in undeveloped areas or offshore
- high bandwidth is required;
- it is difficult to negotiate a right of way for cable;
- cable is expensive to lay or is likely to suffer physical disturbance due to agriculture, construction work or vandalism.

Typical examples of the use of private microwave are:

- communications between offshore platforms and the link to shore;
- communications to exploration and production sites in undeveloped desert or jungle areas;
- linking facilities across estuaries, rivers or lakes or across public roads or land belonging to third parties;
- communicating across large tankfarms;
- connecting private telephone networks to the local PTT system or for cross town links between offices.

In some countries the PTT or a common carrier may have sufficient resources and be prepared to engineer, procure and install the necessary equipment. In other countries the Principal may have to carry out some or all of the necessary work.

3. DESIGN

3.1 REQUIREMENTS

The early planning should have been completed to a sufficient degree that the locations to be served, the type of system required (see Appendix 1) and the capacity have been determined. The availability targets should also be set as part of the user requirements. Availability includes radio propagation, equipment failure, as well as technician and operator error, all of which can be controlled or influenced during design.

Typical availability of a private microwave system would be 99.98% which equates to a cumulative outage of about 9 minutes per month. This is likely to consist of numerous short-duration outages resulting in interruptions to telephone service or even clear-down of all calls in progress and the slowing of data transfer. Availability significantly less than 99.98% would be unlikely to provide a satisfactory service and the local PTT may not allow connection to their network.

International standards covering outage due to radio propagation are listed in DEP 32.71.00.11-Gen. sections 3.1 and 3.2. The appropriate standard should be chosen.

Outage due to equipment failure is more difficult to quantify since the unit MTBF (mean time between failure) is seldom known. Manufacturer's quoted MTBF are often obtained under ideal conditions which are not normally found in field operations. The time to travel to a failed site to make repairs is usually so long that standby equipment and automatic change-over are essential in most cases. This is called protected equipment. Non-protected equipment should only be considered where an alternative communications link exists or long outages will not affect essential services.

Remote monitoring should be used to inform maintenance personnel about failed equipment. The layout of the alarm display and its location(s) should be carefully considered as part of the overall maintenance response. (See section 4).

Logical, uncomplicated layout of equipment and clear labelling of the main signal paths and power feeds will help to reduce outage due to technician and operator error.

3.2 CLEARANCE CRITERIA

See (Appendix 2) for information on radio propagation. The range of K factors over the year is not usually known in advance. Choosing the clearance as advised below is a first approximation to link design. The design can be refined if sufficient information becomes available about the value of K with time.

Link performance can only be assessed in the long term and defects in design may not become apparent immediately after commissioning. Recording in accordance with ITU recommendations should be included in the remote monitoring system (see 3.7) to analyse and document the performance over a 12 month period. The Contractor should be required to modify the link to meet any shortfall of performance against the original design objectives.

3.2.1 Normal non-reflective paths

As an initial step in meeting the specified availability the following minimum clearance should apply over the whole path:

Capacity up to 2 Mbit/sec:

= $0.6 F_1$ plus 3 metres at $K = 1$

Capacity more than 2 Mbit/sec or where high reliability is required:

= $0.3 F_1$ at $K = 0.6$ or $1.0 F_1$ at $K = 1.33$ whichever is greater

where F_1 is the radius of the first Fresnel zone and K is the equivalent earth radius factor. (see explanation in Appendix 2.)

For very short links with a single obstruction, diffraction may provide sufficient signal to meet the availability criteria. Computer calculation (see section 3.12) should be carried out to simulate the performance.

Where a clear line of sight (or workable diffraction) is not possible either because of distance or multiple obstructions, one or more repeaters will be required. Each hop should be designed to have the necessary clearance so that the composite link meets the overall design objectives.

3.2.2 Reflective paths

In addition to the conditions in (3.2.1) the path should be tested for K factors between 1.33 and infinity. If possible, sites should be selected where the terrain or obstacles provide screening or blocking of all potential reflective paths such as bodies of water or smooth flat ground. If this is not possible the antenna at one end should be positioned at a high site and the other end at a low site to bring the reflecting point nearer to the low end. Illumination of the reflecting plane should be not more than the first Fresnel zone. If this requirement cannot be met then diversity should be used. See (Appendix 2).

3.2.3 Open rolling terrain

In open terrain where the path may have trees and other obstacles at some points and barren desert or hills at others, clearance of the trees and obstacles should be considered to meet the criteria in (3.2.1) while the desert or hills should be considered as possible reflectors as in section (3.2.2).

3.3 REPEATERS

One or more repeaters may be required on the route because it is not possible to achieve sufficient clearance using a direct link. The type and location of the repeaters should be chosen to minimise cost while meeting the availability criteria. Choosing sites with easy access is particularly important since installation and operating costs rise considerably if specialist transport such as helicopters is required on a regular basis.

3.3.1 Passive repeater

If a short path is blocked by one or more obstacles and the computer calculation shows that there is insufficient diffraction to meet the availability criteria, a passive repeater should be considered to get round the obstacle(s). The passive repeater could be a reflecting billboard which is situated off to one side of the path allowing narrow angles of reflection, or side-by-side billboards which provide a double reflection and channel the signal e.g. over a ridge and down a valley. The billboards act like microwave mirrors.

Special kinds of passive repeater (e.g. a periscope antenna) can be used between ground level and a high tower to avoid long feeder runs which have a high loss.

Passive repeaters require careful design and can only be used in a minority of circumstances.

3.3.2 RF (Radio Frequency) repeater

A radio frequency repeater uses amplifiers between the two back-to-back antennas. These amplify the signals in both directions without changing the frequency. Antennas with a high front-to-back ratio and careful orientation allow gains of 20 to 30 dB in each direction before the system becomes unstable. Because any interfering signals are also rebroadcast, RF repeaters are useful in only a few locations.

3.3.3 IF (Intermediate Frequency) repeater

IF repeaters are used where amplification is required but where no access is needed to the traffic path at the repeater site. Since there is only a change of RF frequency and no demodulation of the carriers, IF repeaters simplify the electronics, reduce power consumption, and minimise noise and distortion. They were common in the days of analogue links - less common with digital links.

3.3.4 Demodulating repeater

The normal repeater demodulates the incoming carrier and then re-modulates the outgoing carrier. Full or limited access can be arranged to the traffic paths. The demodulating repeater can be regarded as two back-to-back terminals.

3.3.5 TDMA (Time Division Multiple Access) repeater

As well as being a standard radio repeater to extend the system range, a TDMA repeater can also provide local telephone and data services.

3.3.6 Choice of repeater site

The choice of location of the repeater(s) will depend on:

- topography and path profiles of the component hops;
- freedom from interference to or from other telecommunication equipment or from high-power radars;
- reuse of existing sites, buildings or structures;
- cost of site preparation e.g. clearance, levelling, tower foundations and lightning protection;
- availability or cost of providing access (e.g. road or helipad);
- availability or cost of providing mains power or alternative energy;
- zoning and building regulations;

- acceptance by the local community and security considerations.

Each microwave hop in the chain is designed separately. Since there are many variables, including location and height of the towers at each end, several iterations are required to reach the optimum solution.

To reduce the possibility of overshoot of signal from one site to another in the same chain, some zigzag of the route should be considered especially if frequencies are to be reused elsewhere in the chain. This is particularly important in those areas of the world where ducting is common.